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November 7, 2008

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BY ELECTRONIC FILING

Ms. Marlene H. Dortch
Secretary
Federal Communications Commission
445 Twelfth Street, S.W.
Washington, DC 20554

Re: **GE Healthcare *Ex Parte***
ET Docket No. 08-59

Dear Ms. Dortch:

GE Healthcare ("GEHC") hereby provides notice of permitted *ex parte* communications in the above-referenced proceeding. On November 6, 2008, Dr. Paul Kolodzy, Kolodzy Consulting, and the undersigned, counsel to GEHC, met with Julius Knapp, Alan Stillwell, Bruce Romano, Gary Thayer, Geraldine Matise, Ira Keltz, Jeff Dygert, and Mark Settles from the Commission's Office of Engineering and Technology. Tim Kottak, Engineering General Manager, GEHC, Neal Seidl, Wireless System Architect, GEHC, and David Davenport, Electrical Engineer, GE Global Research, also joined the meeting by teleconference.

During the meeting, Dr. Kolodzy and I distributed the attached presentation and various documents cited or discussed in the presentation or already submitted in the proceeding record, including the documents attached hereto. Following such distribution, the parties discussed several MBANS rule modifications proposed by GEHC in response to concerns that have been raised in the proceeding.

In particular, GEHC reiterated its decision to modify its proposed footnote NG186 to clarify that the regulatory status of incumbent 2360-2400 MHz services would be unchanged and that MBANS operations would be secondary to all primary services, whether or not they operate in the 2360-2400 MHz band. GEHC also reiterated its proposal, discussed in its September 18, 2008 *ex parte*,[1] to limit MBANS operations in the 2360-2390 MHz band to health care facilities only. In addition, GEHC noted its support for the establishment of geographic exclusion zones around all 157 aeronautical mobile telemetry ("AMT") receive sites (regardless of whether S-Band AMT operations are occurring at the sites). Under the proposal, no MBANS operations in the 2360-2390 MHz band would not occur within such geographic exclusion zones. GEHC stressed that these MBANS proposal modifications serve to simplify significantly the compatibility issues that must be addressed by the Commission before authorizing MBANS operations in the 2360-2400 MHz band. GEHC also noted that such modifications have helped to crystallize and narrow the issues that are in dispute regarding the MBANS proposal, arguing that a proper foundation now exists for the issuance of a Notice of Proposed Rulemaking proposing a new MBANS spectrum allocation.

In addition, GEHC discussed the fact that several parties, including Philips, Draeger-Seimens, SpaceLabs, AdvaMed and Baxter have submitted filings in the past month supporting the need for and benefit of an MBANS spectrum allocation and that the Wireless Communications Association International, Inc. ("WCA") has filed a letter stating that, given GEHC's proposed modification of footnote NG186, it has no further objection to the MBANS proposal.[2]

During the meeting, the parties also discussed a number of technical issues relating to the coexistence of MBANS and AMT operations in the 2360-2400 MHz band. In particular, Dr. Kolodzy stated that the analysis previously submitted by the Aerospace & Flight Test Radio Coordinating Council ("AFTRCC"), which purported to show that MBANS devices could not coexist with AMT without very large separation distances, is flawed in two respects. First, Dr. Kolodzy pointed out that the AFTRCC analysis uses an overly simplistic static minimum coupling loss ("MCL") approach, and second, he pointed out that the AFTRCC analysis inappropriately substitutes an admittedly stringent absolute power flux density ("PFD") threshold from ITU-R Recommendation M.1459 for the actual AMT link criteria (*i.e.*, AMT signal-to-interference ratio). Dr. Kolodzy explained that such a conservative, noise-limited analysis approach is poorly suited to the task of accurately evaluating the coexistence of mobile terrestrial systems such as AMT and MBANS. He pointed out that such an approach is particularly improper for application in the 2360-2395 MHz band due to the sources of interference into the band that currently exist, including Amateur Radio, Part 27 WCS transmitters, Part 18 ISM devices and ubiquitous Part 15 unlicensed devices.

During the meeting, Dr. Kolodzy discussed compliance data from Part 15 unlicensed devices showing that actual spurious emissions into the AMT band from many ubiquitously deployed and routinely used products are sufficient to violate the M.1459 PFD criteria at a range of several kilometers. He also noted that since AMT is coexisting today with literally millions of such uncontrolled devices that violate, by substantial

[1] *Ex Parte* filing by GE Healthcare, ET Docket No. 08-59 (filed Sept. 18, 2008) ("*GEHC September 18 Ex Parte*").
[2] *Ex Parte* filing by the Wireless Communications Association International, Inc., ET Docket No. 08-59 (filed Sept. 25, 2008).

margins, the protection criteria AFTRCC has put forth in this proceeding to argue against the proposed MBANS allocation, this protection criteria must be flawed.

Dr. Kolodzy suggested that the proper approach for evaluating MBANS/AMT coexistence is via a statistical analysis that takes into account the actual AMT link parameters, such as the Monte Carlo analysis performed by GEHC and documented in its September 18, 2008 *ex parte* using the industry-accepted SEAMCAT tool.[3] Dr. Kolodzy explained that, according to parameters provided by AFTRCC and the M.1459 recommendation, the AMT link appears to be generally robust in the sense that on average it has substantial excess margin. On the other hand, Dr. Kolodzy pointed out that the AMT link also appears to be imperfect in the sense that it can be expected to exhibit an outage rate of greater than zero even in the complete absence of interference. Dr. Kolodzy emphasized that evaluation of coexistence for such a system must focus on the probability of *harmful* interference and stated that the GEHC analysis, which concluded that 9.7 km is the upper bound of the geographic separation sufficient to prevent harmful interference to AMT for reasonable worst-case scenarios, was sound and conservative. During the meeting, Dr. Kolodzy also cited the recent ECC draft report 121 regarding coexistence of aeronautical telemetry and “PWMS” wireless microphones operating in the L-band, noting that the draft report’s finding that coexistence is possible generally comports with the findings of GEHC’s analysis.

Finally, Dr. Kolodzy pointed out a number of concerns regarding the validity of the Learjet field tests and the associated report and conclusions submitted by AFTRCC as follows:

- The tests did not demonstrate any actual observed harmful interference (actual AMT outage) effects beyond 0.7 miles separation, and all claims about the tests having demonstrated that harmful interference would occur at farther distances are merely extrapolation based only on violation of the overly conservative M.1459 PFD limit.
- In conducting the field tests, Learjet used continuous narrowband test signals that were not representative of proposed MBANS devices (*e.g.*, the test signals used much higher power spectral density than the proposed MBANS rules would permit and were not bursty or frequency hopped). These may well have been more likely to cause the failure mode (*i.e.*, loss of lock by the AMT tracking antenna) that was observed.
- Learjet’s reported measured signal levels were not plausible, as they exceeded the expected n=2.4 path loss (due to reported ground clutter) by as much as 30 dB with an average of 19.2 dB and with four out of five even exceeding the theoretically bounding *free space* loss.
- Although AFTRCC later suggested that additional “system gain” not disclosed in the test report may have been present during the field tests, no further details have been disclosed.

[3] *GEHC September 18 Ex Parte* at Appendices.

In accordance with Section 1.1206(b) of the Commission's rules, this letter is being filed electronically with your office.

Sincerely,

/s/ Ari Q. Fitzgerald
Ari Q. Fitzgerald
Counsel to GE Healthcare

cc: Julius Knapp
Alan Stillwell
Bruce Romano
Gary Thayer
Geraldine Matise
Ira Keltz
Jeff Dygert
Mark Settles

Medical Body Area Network Service (MBANS) Proposal – Update on Status and Aeronautical Mobile Telemetry Coexistence

GE Healthcare

Presentation to the FCC OET

ET Docket No. 08-59

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Meeting objective

"GE Healthcare urges the Commission to move expeditiously by preparing an NPRM which . . . proposes the new spectrum allocation and rule changes necessary to make the next generation of wireless medical devices a reality."

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Brief Update on Recent Developments

Based on feedback from the Commission, NTIA, AFTRCC and other interested parties, GEHC proposed several modifications to the MBANS rules:

- Clarified proposed footnote NG186 in the Table of Allocations to state that aeronautical mobile use is prohibited only for MBANS devices and that the status of all currently-allocated services (including AMT) remains unchanged.
- Also modified proposed footnote NG186 to clarify GEHC's intent that MBANS operations be secondary to all primary services, regardless of frequency band.
- Proposed geographic exclusion zones for MBANS operations in the 2360-2390 MHz band around all AMT receive sites to further reduce the potential for interference while still creating an extremely valuable resource from otherwise fallow spectrum – "belt and suspenders" approach.

Recent supportive / concurring filings in the record:

- Philips
- Draeger-Seimens
- SpaceLabs
- AdvaMed
- Baxter
- Toumaz
- ST+D
- WCA

A 9.7 km exclusion radius, which the latest conservative analysis shows to be more than sufficient, would make the entire 2360-2400 MHz band available in over 99.5% of CONUS while one quarter of the band (2390-2400 MHz) would be available everywhere.

GEHC has submitted rigorous new coexistence analysis that clearly demonstrates viability.

With the remaining issues substantially narrowed,

an NPRM is the appropriate next step.

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Coexistence Topics Executive Summary

- GEHC has recently completed new much more rigorous analysis that indicates the viability of coexistence between MBANS and AMT.
  - Monte Carlo statistical analysis using industry-accepted tools indicate acceptable SNR levels with modest back-off range
  - Recent ECC draft report 121 supports the viability of the MBANS proposal by determining that aeronautical telemetry and "PWMS" wireless microphones operating in the L-band with 50 mW-per-200 kHz emissions limit can coexist.
  - AFTRCC analysis is based entirely on static MCL calculations of absolute power flux density (ITU M.1459), which is not a *necessary* condition for coexistence
- OOBE of legal, FCC certified, and ubiquitously deployed Part 15 devices in the 2400-2483 MHz band already violate AFTRCC's requested PFD limit in the AMT band without any adverse effects noted
- Learjet Tests provided by AFTRCC are notable in two ways:
  - Used continuous narrowband test signals that were not representative of proposed MBANS devices (e.g., the test signals used much higher power spectral density)
  - The tests did not demonstrate any actual observed harmful interference (outage) effects beyond 0.7 miles separation— consistent with GEHC statistical analysis.
- The evidence is clear that coexistence is possible and readily manageable.

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AFTRCC's Coexistence Analysis – Simplistic, Flawed and Misleading

AFTRCC's static minimum coupling loss (MCL) analysis computes only the separation distance required to satisfy an extremely stringent absolute power flux density (PFD) limit that it invokes without justification from ITU-R Recommendation M.1459.

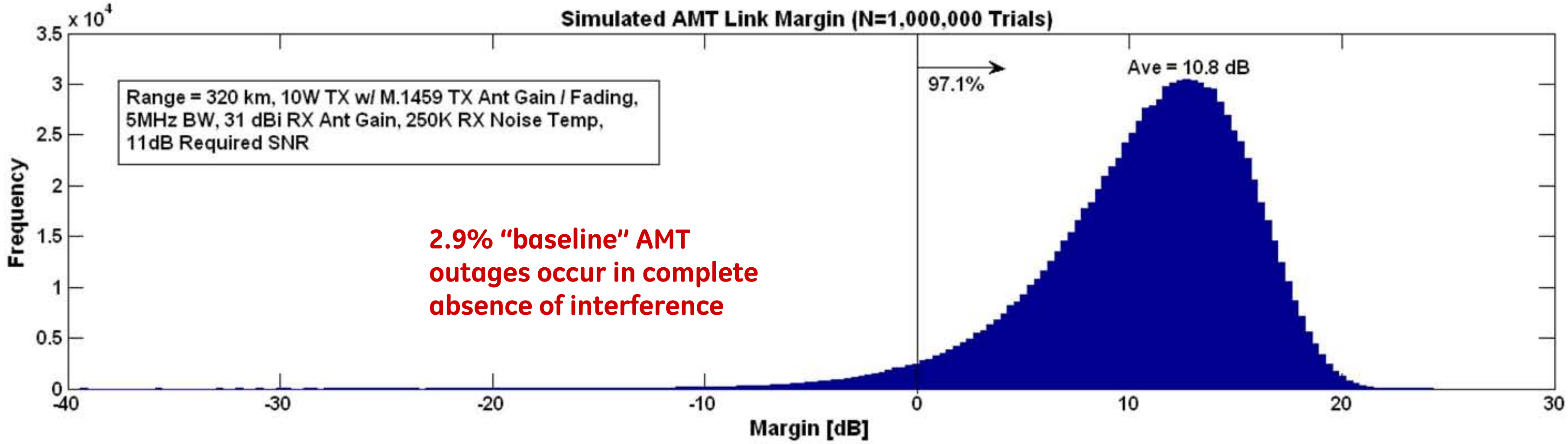
- Static MCL approach is overly simplistic and conservative.
- Closer examination proves that AFTRCC's approach must be flawed since it yields absurd results when applied to existing interference sources in the band with which AMT is already coexisting.

AFTRCC's analysis ignores the fact that significantly less separation is required to satisfy the actual AMT link budget (*i.e.*, that sufficient AMT SINR is maintained) vs. M.1459 PFD limit.

In fact, AFTRCC's analysis completely neglects to examine *any* aspects of the actual AMT link at all.

AFTRCC's analysis improperly substitutes the M.1459 PFD limit for the actual AMT link criteria (e.g. SINR) and also employs unrealistic static MCL computations thus resulting in unreasonable and misleading separation distances vs. modest separation that follows from a proper analysis.

Actual Characteristics of Typical AMT Link That Are Not Accounted for in AFTRCC Analysis…



- At most points in time, AMT link has copious excess margin.
- AMT outages are driven by long "tail" of fading distribution – outages will be relatively common, even with zero interference.
- Although imperfect, the AMT link is quite robust – outage rate is insensitive to moderate interference.
- For cases where a perfectly-reliable AMT link really is required, it would best be achieved through techniques like coding or diversity, which can exploit the significant excess margin, and not by preserving fractional dBs of SNR by seeking to limit interference to unrealistically low thresholds.

Either: Outage rates of several percent are, in fact, acceptable and are being tolerated already,

Or: The AMT link budget actually has more margin than AFTRCC has acknowledged (e.g. not operating out to full 320 km, using more TX power than claimed, actual fading is less severe than claimed 30 dB, incorporating coding, diversity, or other mitigation techniques, etc.).

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ITU-R M.1459 Recommendation – Very Conservative by Its Own Admission…

"When interference calculations are being made, worst-case scenarios are likely to be used, which could tend to lead to the conclusion that co-frequency or co-channel sharing by different services cannot occur. General technical parameters are used… [which] may not reflect the actual proposed usage by administrations."

"[A]dditional studies have been introduced in the ITU-R for determining the probability of interference to telemetry stations in the aeronautical mobile service which could lead to less stringent protection values…"

"[T]elemetry stations in the aeronautical mobile service have a wide range of characteristics and some may have less stringent protection criteria values…"

"pfds are currently specified in a 4 kHz bandwidth . . . limiting the interference levels in such a narrow bandwidth may lead to overly protective criteria."

"The maximum practical [tolerable I/N] value is considered to be approximately 0.5 (-3 dB)."

Yet the –180 dBW/m^2/4 kHz PFD limit that M.1459 recommends actually equates to an I/N ratio of –9.4 dB for a typical 31 dBi AMT receive antenna.

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AFTRCC Inappropriately Applies M.1459 PFD Limit

The M.1459 power flux density limit is very stringent in general and is particularly inappropriate for application to the 2360-2395 MHz AMT band, as is done by AFTRCC.

Unlike other AMT bands, the 2360-2395 MHz band already has significant noise due to fundamental and spurious emissions from a variety of non-AMT sources operating in the same or adjacent bands.

Applying AFTRCC's analysis, which is based on the ITU-R M.1459 PFD limit, to permitted emissions from these existing interference sources yields absurd results…

Interference Source	Separation distance required to satisfy M.1459 PFD limit using n=2.4 propagation exponent
Single typical amateur radio transmitter	10W fundamental emissions: **1,370 km,** -50 dBc OOBE: **11.3 km,** -60 dBc OOBE: **4.4 km**
Single Part 27 WCS device	OOBE[1]: **17.8 km**
Single Part 18 ISM device	OOBE[2]: **7.0 km**
Single 2.4 GHz Part 15 unlicensed device	2360-2390 MHz Average OOBE[3]: **1.2 km** 2360-2390 MHz Peak OOBE[4]: **8.1 km** 2390-2395 MHz -20 dBc OOBE[5]: **162 km**

Ubiquitous, Uncontrolled Devices

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[1] *See* 47 CFR 27.53(a).

[2] *See* 47 CFR 18.305 and FCC MP-5-1986 Measurement Procedure.

[3] *See* 47 CFR 15.209(a).

[4] *See* 47 CFR 15.209(a) and 15.35(b); AFTRCC has suggested that peak, rather than average, emissions should be used in anglysis.

[5] *See* 47 CFR 15.247(d).

Actual Part 15 OOBE will already violate PFD Limit

Part 15 devices are:

- **Highly uncontrolled**
- **Ubiquitous**
- **Portable / used outdoors**

A review of compliance data revealed that emissions from many real-world devices are commonly at or near their maximum permissible limits in the AMT band.

Data shows this to be *the rule, not the exception*, for popular "Wi-Fi" devices.

Wide array of products (*e.g.*, access points, notebook computers, smartphones, digital music players) from leading manufacturers, including many products designed for portable and/or outdoor use.

Phenomenon is not limited to any one 802.11 standard, modulation type, data rate, or channel.

With no assurance of several km separation from AMT sites, the M.1459 PFD limit cited by AFTRCC can be expected to be significantly exceeded *today*.

Selected examples…

Less than 1 dB margin to limit is common.

Manufacturer	Device Description	FCC ID	Freq. [MHz]	Emission [dBuV/m@3m]	Test Condition
3Com	AP3150 Wi-Fi Access Point	O9C-AP3150	2386.20	53.70 Ave	802.11b, channel 1, antenna 2
			2390.00	53.55 Ave	802.11g, channel 1, antenna 2
3Com	AP3950 802.11n Wi-Fi Access Point	O9C-AP3950	2389.93	73.64 Peak	802.11n, 20MHz channel 1
			2390.00	53.57 Ave	802.11n, 20MHz channel 6
			2390.00	53.92 Ave	802.11n, 40MHz channel 1
			2386.36	52.07 Ave	802.11b, channel 1
			2390.00	53.28 Ave	802.11g, channel 1
Apple	iPod Touch	BCGA1288	2390.00	53.08 Ave	802.11g, channel 1, horz pol
Aruba	AP-70 802.11b/g Wi-Fi Access Point	Q9DAP70SDR	2390.00	52.28 Ave	802.11g, channel 1, 6dBi antenna-2
			2390.00	73.30 Peak	802.11b, channel 1, 12dBi antenna-7
Aruba	AP-120 802.11n Wi-Fi Access Point	Q9D AP120121SDR	2390.00	52.54 Ave	802.11b, channel 1, integral ant, ART = 17.5
			2390.00	73.19 Peak	802.11g, channel 1, integral ant, ART = 13.5
			2390.00	73.37 Peak	802.11n HT-20, channel 1, integral ant, ART = 12
			2390.00	53.08 Ave	802.11n HT-40, channel 1, integral ant, ART = 9.5
Asustek	R1E Notebook PC with integrated 802.11n Wi-Fi	MSQR1E	2388.38	52.44 Ave	Mode 4: 802.11n(20M) (2412MHz) (Ant A), horz pol
Broadcom	Wi-Fi module for notebook PCs (e.g. Dell D620)	QDS-BRCM1020	2389.87	53.95 Ave	802.11g, channel 1, 18 dBm, vert pol
Cisco	AIR-AP1141 / 1142 802.11n Access Points	LDK102069, LDK102070	2386.60	53.44 Ave	2412 MHz, 11 Mbps, Legacy CCK, Dual Paths
			2390.00	54.00 Ave	2412 MHz, 54 Mbps, Non HT-20, Single Transmit Paths
			2390.00	53.61 Ave	2412/2432 MHz, 54 Mbps, Non HT-20 Beam Forming
			2389.20	73.58 Peak	2412/2432 MHz, 54 Mbps, Non HT-40 Dupl, Dual Paths
Cisco	Aironet LAP1510 802.11b/g outdoor Access Point	LDK102058	2385.90	53.35 Ave	802.11b, channel 1, 5.5 dBi antenna
			2390.00	53.89 Ave	802.11g, channel 1, 5.5 dBi antenna
D-Link	DIR 825 802.11n Wi-Fi Router	KA2DIR825A1	2390.00	72.88 Peak	802.11n (20 MHz), channel 1, vert pol
			2382.00	52.74 Ave	802.11n (40 MHz), channel 1, vert pol
Dell	Notebook PC	E2K24GBRL	2390	52.54 Ave	802.11g, channel 1, vert pol
			2385.2	52.87 Ave	802.11b, channel 1, horz pol
IBM	ThinkPad G40 2387, 2388, 2389 notebook PCs	ANO 20020306A1L	2368.00	53.10 Ave	802.11g, channel 6, horz pol
Linksys	WRT600N 802.11n Wi-Fi Access Point	WRT600NV11	2390000	53.92 Ave	802.11g, 2417MHz, pwr setting 0x33xx, vert pol
			2390000	53.84Ave	802.11 SISO, 2427MHz, pwr setting 0x41xx, vert pol
			2389.6	53.8 Ave	802.11n 40MHz, 2422MHz, pwr setting 0x3f3d, vert pol
			2388.6	53.92 Ave	802.11n 20MHz, 2412MHz, pwr setting 0x433e, vert pol
Meru	AP-150 802.11b/g Wi-Fi Access Point	RE7-AP150R2	2386.00	53.25 Ave	802.11b, channel 1
			2390.00	53.82 Ave	802.11g, channel 1
			2390.00	53.70 Ave	802.11g Turbo, channel 6
Meru	OAP-180 802.11b/g Outdoor Wi-Fi Access Point	RE7-OAP180	2385.60	53.67 Ave	802.11b channel 1, antenna 5
			2390.00	53.42 Ave	802.11g channel 1, antenna 5
			2390.00	53.84 Ave	802.11g turbo channel 6, antenna 5
Nokia	E61 RM-89 Wi-Fi Enabled smartphone	PYARM-89	2390.00	71.32 Peak	802.11g, 48 Mbps symbol rate, channel 1
Palm	Treo Pro Wi-Fi Enabled smartphone	O8F-SKYG	2389.99	52.43 Ave	802.11b, channel 1, horz pol
			2390.00	72.44 Peak	802.11g, channel 1, horz pol
Proxim	ORINOCO AP-700 802.11b/g Access Point	HZB-AP700	2390.00	52.40 Ave	802.11b, channel 1, antenna 4, vert pol
			2390.00	52.30 Ave	802.11b, channel 6, antenna 5, vert pol
			2360.00	52.80 Ave	802.11b, channel 11, antenna 5, vert pol
			2378.00	53.20 Ave	802.11b, channel 11, antenna 5, vert pol
RIM	BlackBerry 8820	L6ARBG40GW,	2390.00	51.20 Ave	802.11b/g, channel 1, vert pol
Samsung	Q1 Ultra Mobile PC	A3L-NP-Q1	2369.60	53.59 Ave	802.11b, channel 1, foxconn ant, horz pol.
			2390.00	53.57 Ave	802.11g, channel 1, foxconn ant, horz pol.
			2390.00	53.09 Ave	802.11g, channel 1, foxconn ant, vert pol.
			2368.80	53.29 Ave	802.11b, channel 1, KAE ant, horz pol.
			2369.20	53.94 Ave	802.11b, channel 1, KAE ant, vert pol.
			2364.40	53.49 Ave	802.11g, channel 1, KAE ant, horz pol.
Sony	VAIO notebook PC with integrated 802.11g Wi-Fi	AK8PCG6J1L	2389.58	51.28 Ave	802.11g, channel 1
Trapeze	Model 430 802.11n Wi-Fi Access Point	QZE303	2386.36	52.07 Ave	802.11b, channel 1
			2390.00	53.28 Ave	802.11g, channel 1
			2389.93	52.40 Ave	802.11n, 20MHz channel 1
			2389.84	72.93 Peak	802.11n, 20MHz channel 6
			2390.00	53.92 Ave	802.11n, 40MHz channel 3
			2390.00	53.39 Ave	802.11n, 40MHz channel 6

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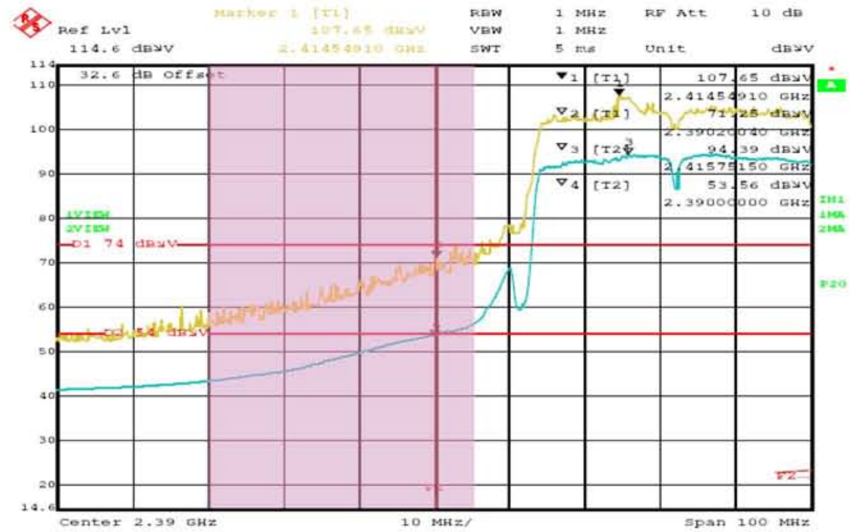
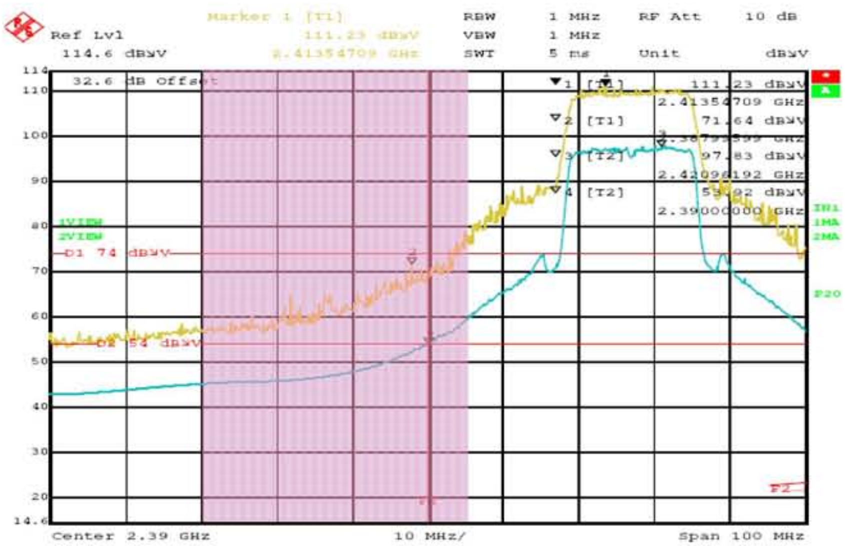
See Ex Parte filing by GEHC, ET Docket No. 08-59 (filed Oct. 30, 2008).

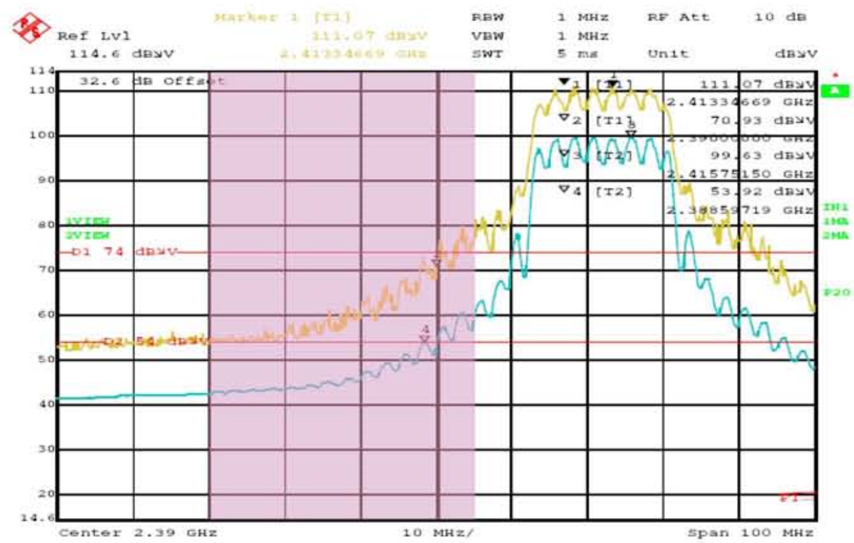
Actual Part 15 Device Emission Examples

Linksys WRT600N 802.11n Access Point[1]



2360-2395 MHz portion of proposed band used by AMT





Significant OOBE occur with multiple Wi-Fi standards, but especially with the newer 802.11g and 802.11n that employ OFDM.

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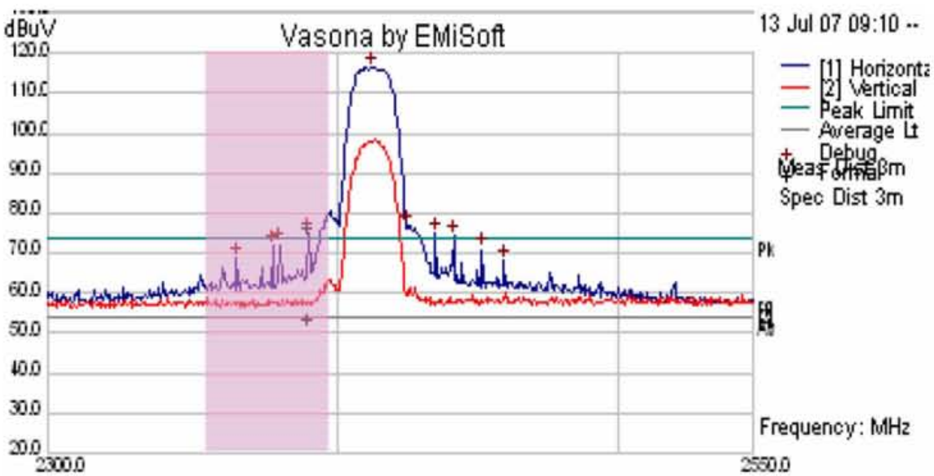
[1] *See* https://gullfoss2.fcc.gov/prod/oet/forms/blobs/retrieve.cgi?attachment_id=789037&native_or_pdf=pdf

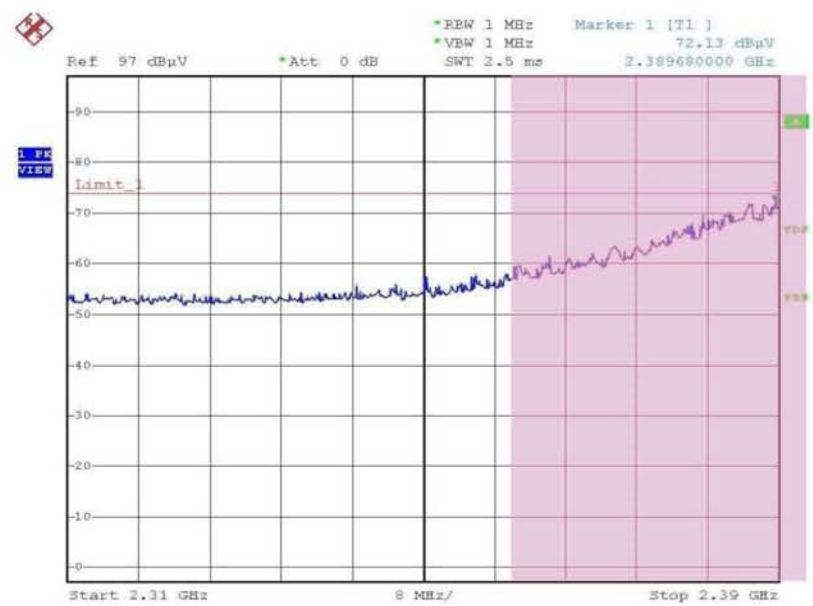
Actual Part 15 Device Emission Examples

Aruba AP-70 802.11b/g Wi-Fi Access Point[1]

Linksys WRT350N 802.11n Access Point[2]

2360-2395 MHz portion of proposed band used by AMT





Significant OOBE occur throughout AMT band, not just at upper end.

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[1] *See* https://gullfoss2.fcc.gov/prod/oet/forms/blobs/retrieve.cgi?attachment_id=820101&native_or_pdf=pdf

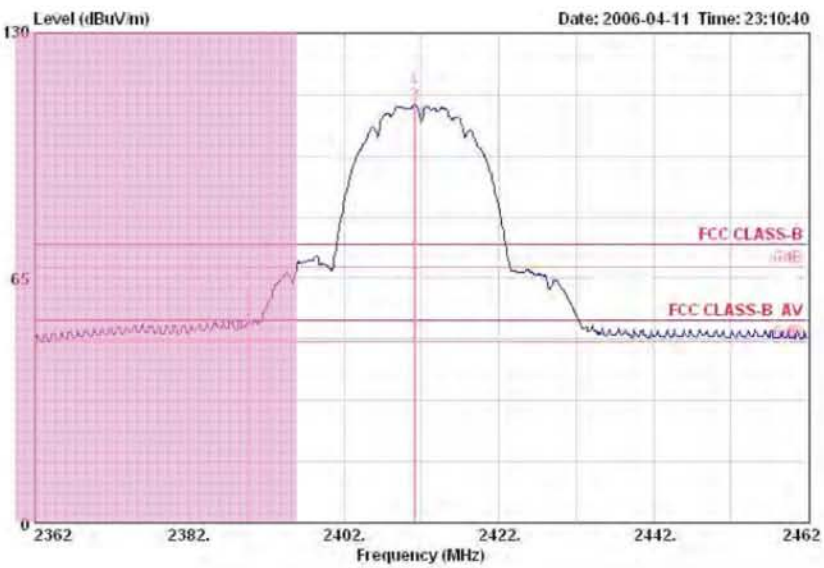
[2] *See* https://gullfoss2.fcc.gov/prod/oet/forms/blobs/retrieve.cgi?attachment_id=711130&native_or_pdf=pdf

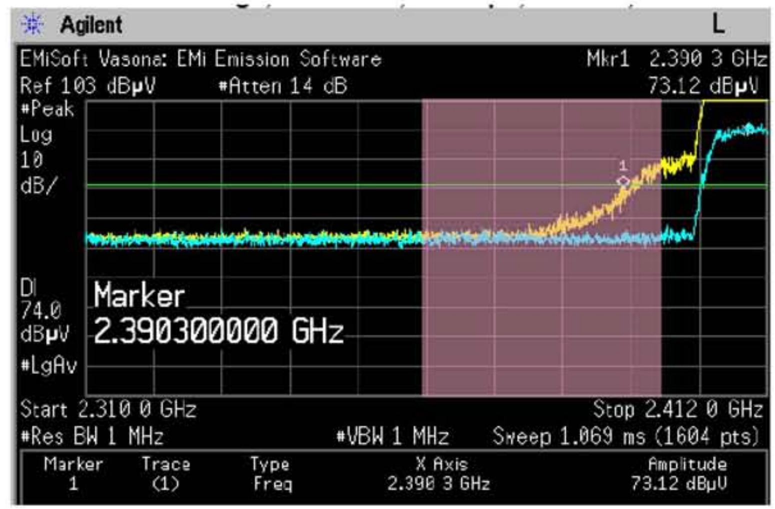
Actual Part 15 Device Emission Examples

Meru OAP-180 Outdoor Wi-Fi Access Point[1]

Cisco LAP1510 Outdoor Wi-Fi Access Point[2]

2360-2395 MHz portion of proposed band used by AMT





Products include high-power outdoor devices increasingly deployed for applications such as Wi-Fi hot-spots and wireless ISP.

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[1] *See* https://gullfoss2.fcc.gov/prod/oet/forms/blobs/retrieve.cgi?attachment_id=799701&native_or_pdf=pdf

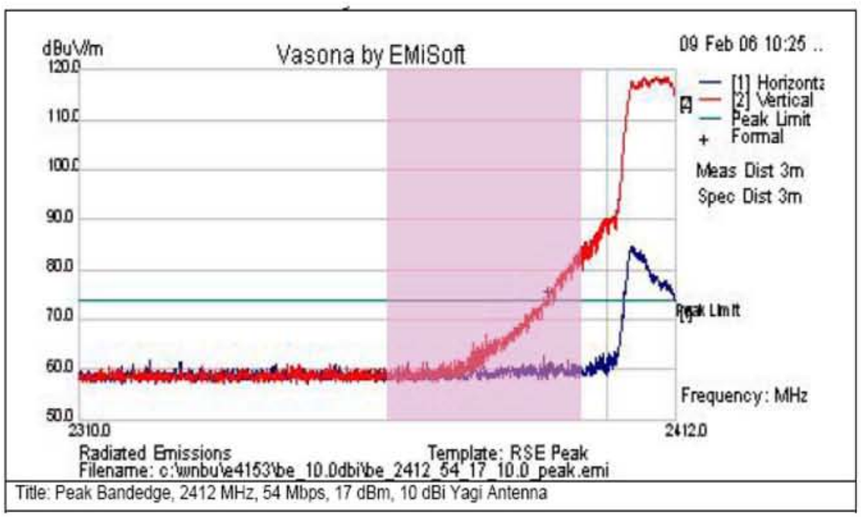
[2] *See* https://gullfoss2.fcc.gov/prod/oet/forms/blobs/retrieve.cgi?attachment_id=595668&native_or_pdf=pdf

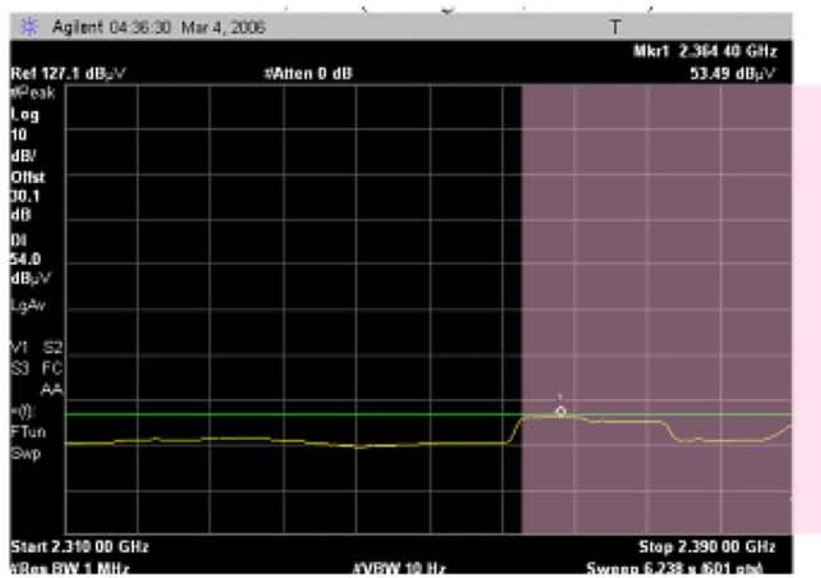
Actual Part 15 Device Emission Examples

Cisco 1250AG Wi-Fi Access Point[1]

Samsung Q1 Ultra Mobile PC[2]

2360-2395 MHz portion of proposed band used by AMT





[1] *See* https://gullfoss2.fcc.gov/prod/oet/forms/blobs/retrieve.cgi?attachment_id=690751&native_or_pdf=pdf

[2] *See* https://gullfoss2.fcc.gov/prod/oet/forms/blobs/retrieve.cgi?attachment_id=641552&native_or_pdf=pdf

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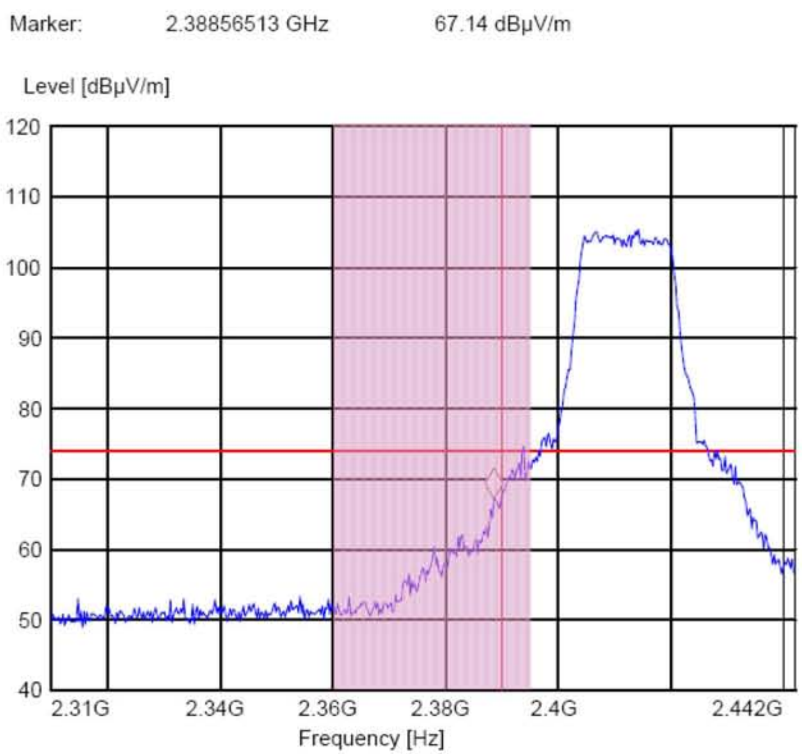
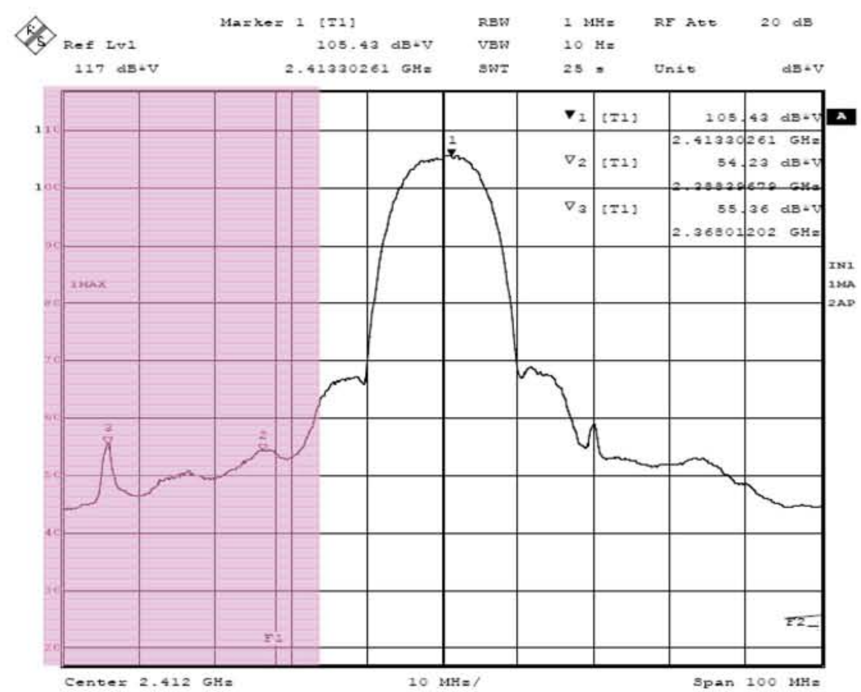
Actual Part 15 Device Emission Examples

Apple iPhone[1]

IBM ThinkPad G40[2]

2360-2395 MHz portion of proposed band used by AMT





[1] *See* https://gullfoss2.fcc.gov/prod/oet/forms/blobs/retrieve.cgi?attachment_id=767386&native_or_pdf=pdf

[2] *See* https://gullfoss2.fcc.gov/prod/oet/forms/blobs/retrieve.cgi?attachment_id=318314&native_or_pdf=pdf

Proper and Realistic Monte Carlo Analysis Confirms That MBANS Can Coexist With AMT

Counter-examples produced by GEHC based on AFTRCC's analytical approach, and supported by actual Part 15 OOBE data and the fact that AMT operations are successfully coexisting with these ubiquitous devices today, demonstrate that AFTRCC's analysis, claims, and conclusions are incorrect.

Even using proper criteria (SINR vs M.1459 PFD), AFTRCC's MCL approach could still only demonstrate the *theoretical possibility* of interference, not quantify the likelihood of harmful interference.

The *actual probability* of harmful interference should be considered, and the widely-accepted Monte Carlo statistical technique can be used to quantify it.

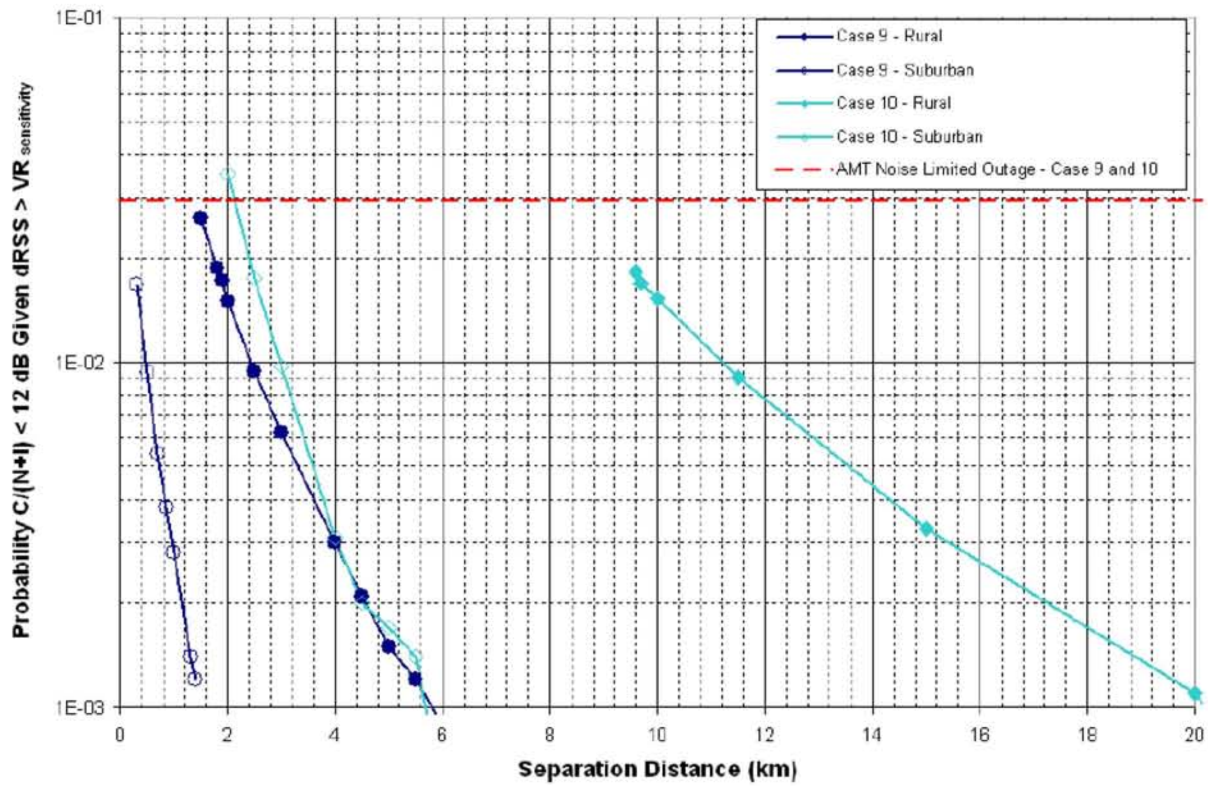
The ITU-R M.1459 recommendation itself cites the need for "additional studies… for determining the [actual] probability of interference to telemetry stations in the aeronautical mobile service which could lead to less stringent protection values…"

GEHC has performed a detailed Monte Carlo analysis using an industry standard SEAMCAT tool that shows the likelihood of harmful interference to be negligible at a modest separation distance (<10 km) for realistic, worst-case scenarios.

Monte Carlo Analysis Confirms MBANS / AMT Coexistence With Modest Separation Distances

Simulated conservative, worst-case scenario:

- 50 interference-contributing MBANS systems in the main beam of an AMT receive antenna.
- Range of AMT transmitter to receiver was fixed at the worst-case of 320 km.
- AMT Propagation model with Rayleigh-like fading from ITU-R M.1459 (should be worst-case with actual AMT link often being significantly better when a strong line-of-sight component is present and/or when diversity is employed).
- MBANS propagation did not include body loss or antenna mismatch



Resulting upper bounds on sufficient separation:

- **≤3.3 km** for suburban propagation.
- **9.7 km** for rural propagation with typical 31 dBi (8′ diameter) AMT antenna.

Compare to AFTRCC's claim that 62 km required for a single 1mW MBANS device.

Recent Analysis by ECC Also Supports the Coexistence Conclusion of GEHC's Analysis

Recent ECC draft report 121, which used SEAMCAT-based Monte Carlo analysis, considered coexistence of aeronautical telemetry and "PWMS" wireless microphones operating at *L-band* (1452-1525 MHz) with 50 mW-per-200 kHz emissions limit.

Despite the the lower operating frequency, narrower bandwidth and substantially higher power of PWMS vs. MBANS devices – corresponding to over 28 dB higher power flux density per Hz at the AMT receiver for the same separation distance – the ECC draft report 121 concludes that:

- PWMS devices can coexist with co-channel aeronautical telemetry unconditionally in urban environments.
- For suburban / rural environments, PWMS devices can coexist with aeronautical telemetry given only relatively modest separation distances of as little as 1.5km.

imagination at work

See Draft ECC Report on Compatibility Studies Between Professional Wireless Microphone Systems (PWMS) and Other Services/Systems in the L Band, Electronic Communications Committee within the European Conference of Postal and Telecommunications Administrations, Report 121, at http://194.182.137.12/367C8D90-8C23-4A16-8B8D-349C5B086E5D

Learjet Field Test Had Several Serious Flaws

Although Learjet's test results are superficially dramatic, upon closer inspection they are neither credible nor compelling…

Learjet used continuous narrowband test signals that were not representative of proposed MBANS devices (*e.g.*, the test signals used much higher power spectral density and did not employ low duty cycle burst transmission or frequency hopping).

These signals apparently interfered not by actually overwhelming desired AMT signal (i.e. violating minimum SINR), but by disrupting the antenna's tracking algorithm. This failure mode seems highly unlikely with actual wideband, bursty, frequency-hopped MBANS signal.

Even still, the test did not demonstrate any actual observed harmful interference effects beyond 0.7 miles separation— All claims about having demonstrated that harmful interference would occur at farther distances are, in fact, merely extrapolation based only on violation of the conservative M.1459 PFD limit.

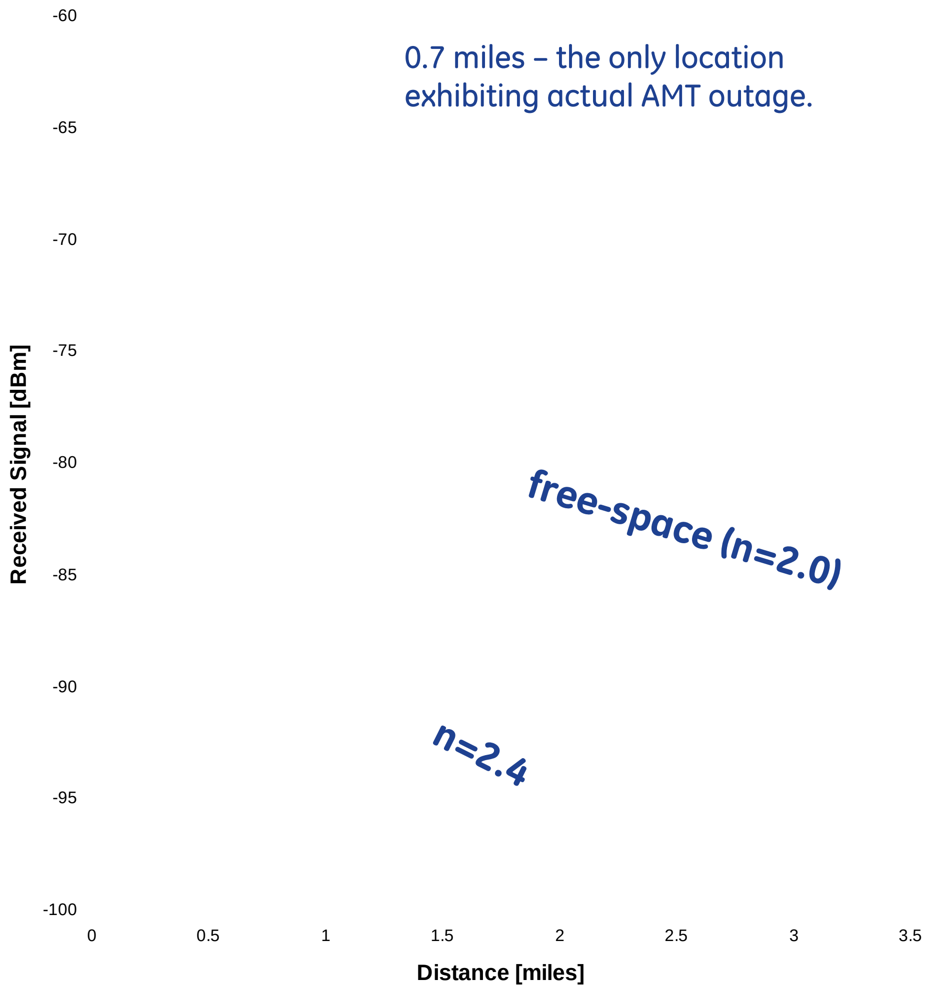
The fixed 0.7 miles separation that Learjet chose for the actual interference test corresponded to the test location yielding the highest received interfering signal power from a number of locations tested.

Learjet's reported measurements of received interfering signal power are completely implausible, greatly exceeding both the expected non-free-space and the theoretically bounding free-space values.

- AFTRCC has since claimed this discrepancy was due to the receive antenna's low-noise amplifier. However, the Learjet test report did not disclose any such additional gain but simply provided measurements that, on their face, greatly exaggerate the received interference.
- Moreover, AFTRCC's recent qualitative explanation notwithstanding, details on the additional gain present in the Learjet field test still have not been disclosed.

Learjet's Questionable Signal Measurements

Comparison of Learjet's Reported Measurements With Theoretically-Expected Measurments



Measurements had nearly constant received signal level of –67 dBm, despite an increase in separation distance of 0.2 to 3.2 miles.

All measurements exceeded the expected n=2.4 path loss (due to reported ground clutter) by as much as 30 dB with an average of 19.2 dB.

Four out of five measurements exceeded even the theoretical free space loss by as much as 16 dB with an average of 6.4 dB.

Was the surrogate MBANS test signal EIRP actually higher than the 1 mW reported?

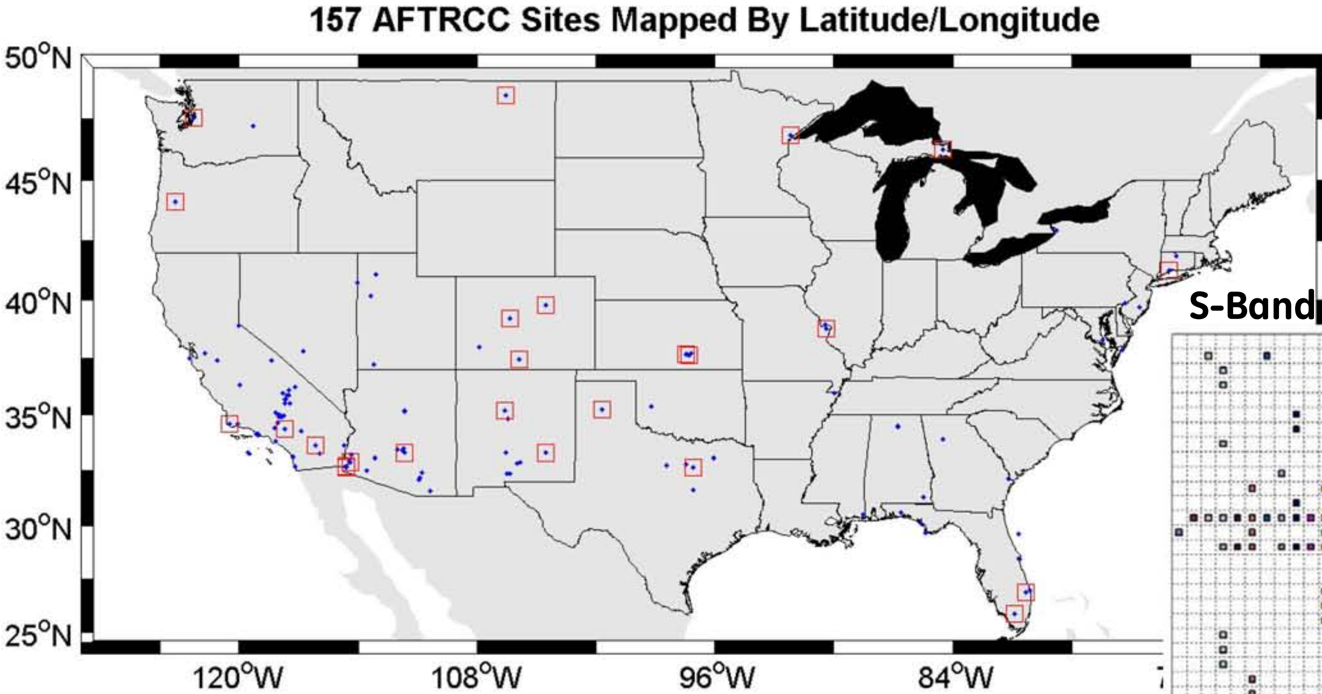
Was the signal being measured actually a distinct and unrelated signal from an unknown radiator (*e.g.*, Part 15 or Part 18 OOBE) that was not part of the intended test?

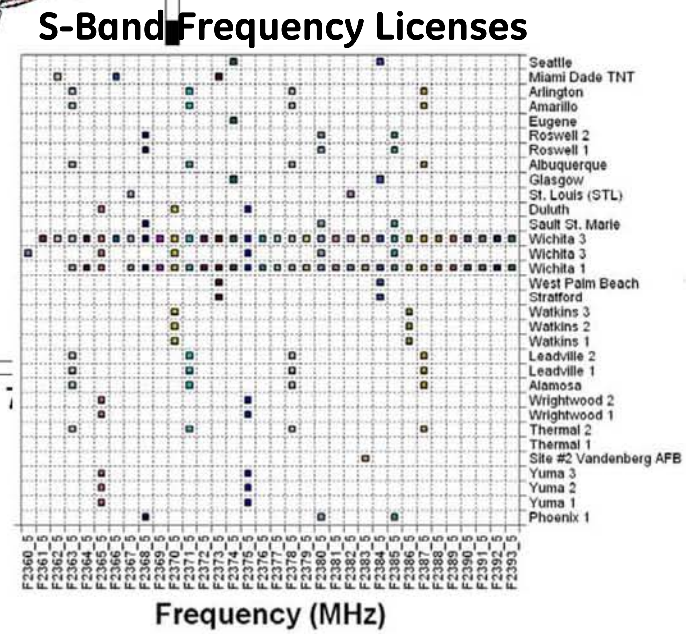
AFTRCC has recently[1] pointed to additional "system gain" that was not mentioned in the original test report to explain discrepancies but details still have not been disclosed.

→ Measurements are suspect and, at best, highly misleading.

[1] *Ex Parte* filing by AFTRCC, Exhibit A, ET Docket No. 08-59 (filed July 28, 2008).

AMT Receive Operations are Very Sparsely Distributed in Space, Frequency and Time.





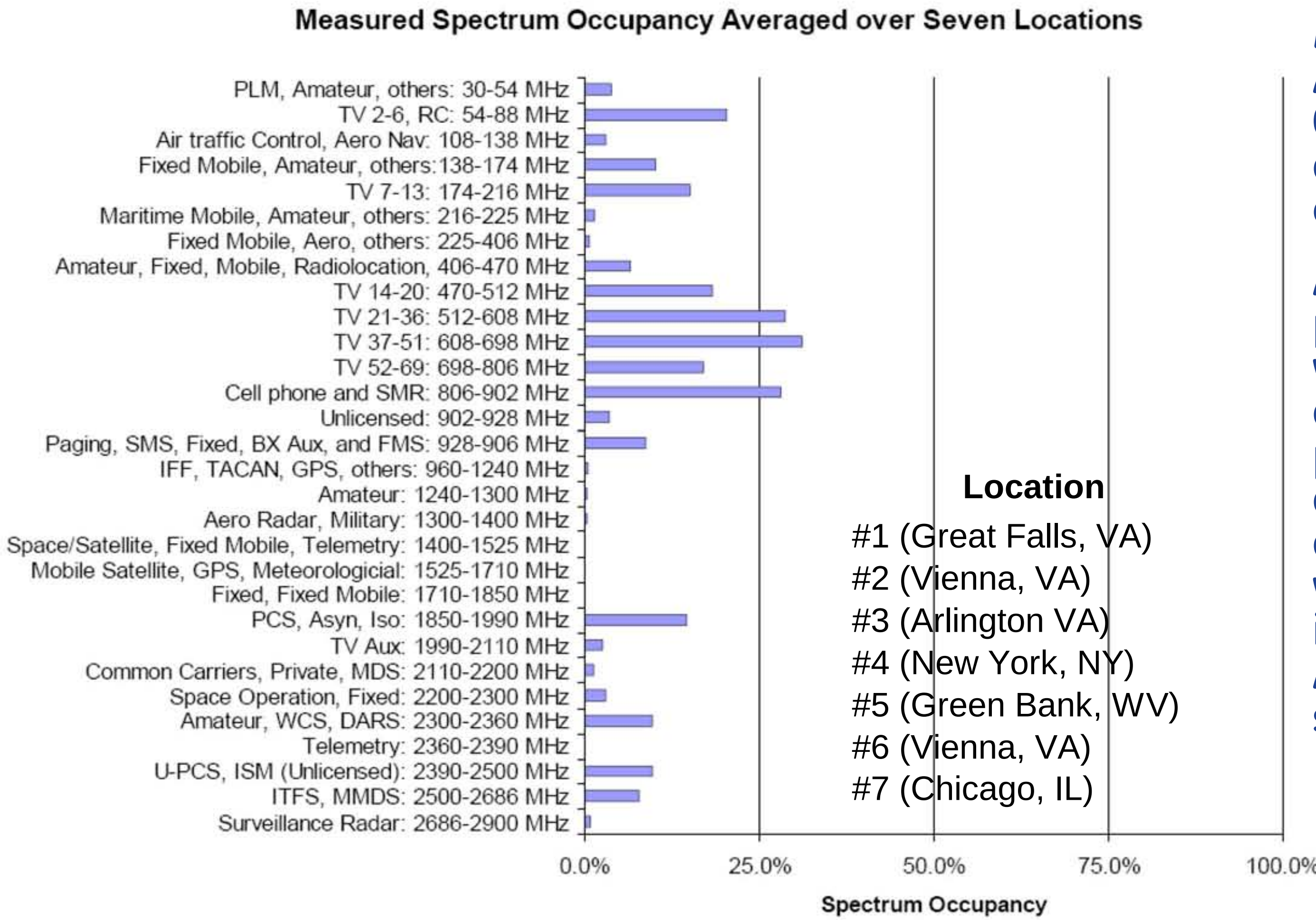
- **Only 32 of 157 AMT sites have an S-band license.**
- **30 AMT sites use 4 or fewer channels out of 34.**
- **Fight test operations are inherently non-continuous and sporadic in nature.**

imagination at work

MBANS rules would protect *all 157 sites* with 2360-2390 MHz exclusion zones

Measurements Confirm Sparse Utilization

Spectrum utilization measurements from NSF's NRNRT research



E.g., utilization of AMT band only 0.021% in Chicago during 46 hours of observation.

AMT usage was not present or, at worst, was below detectable levels proving MBANS devices would be able to operate without receiving interference as AFTRCC has suggested.

See http://www.sharedspectrum.com/measurements/

imagination at work

Thank You!

ECC REPORT 121

Electronic Communications Committee (ECC)
within the European Conference of Postal and Telecommunications Administrations (CEPT)

COMPATIBILITY STUDIES BETWEEN PROFESSIONAL WIRELESS MICROPHONE SYSTEMS (PWMS) AND OTHER SERVICES/SYSTEMS IN THE BANDS 1452-1492 MHz, 1492-1530 MHz, 1533-1559 MHz ALSO CONSIDERING THE SERVICES/SYSTEMS IN THE ADJACENT BANDS (BELOW 1452 MHz AND ABOVE 1559 MHz)

Vilnius, September 2008

0 EXECUTIVE SUMMARY

Following a request from ETSI, WG FM requested WG SE to consider the possible deployment of Professional Wireless Microphone Systems (PWMS), in the bands:

- 1452 MHz to 1492 MHz,
- 1492 MHz to 1530 MHz,
- 1533 MHz to 1559 MHz.

In all of these bands, compatibility and sharing issues need to be assessed in order to identify the preferred sub-bands for PWMS.

This report provides compatibility studies between PWMS and the services possibly affected by their deployment in the bands 1452-1492 MHz, 1492-1530 MHz, 1533-1559 MHz also considering the services in the adjacent bands (below 1452 MHz and above 1559 MHz).

The following table gives an overview of the different results coming from the compatibility studies developed in this report.

Band (MHz)	**SERVICES**				
1429-1452	FIXED	MOBILE	Aeronautical Telemetry		
1452-1492	BS 1452-1479.5 MHz	BSS 1479.5-1592 MHz	Aeronautical Telemetry	Fixed	Mobile
1492-1518	FIXED	MOBILE	Aeronautical Telemetry		
1518-1525	FIXED	MOBILE	MSS (s-E)	Aeronautical Telemetry	
1525-1530	FIXED	SPACE OPERATION (s-E)	MSS(s-E)	Mobile	Aeronautical Telemetry
1533-1535	MSS (s-E)	SPACE OPERATION (s-E)	Aeronautical Telemetry	Mobile	Eess
1535-1559	MSS (s-E)				

(green)	Compatibility is achieved
(orange)	Compatibility may be achieved with mitigation techniques or restriction
(red)	Compatibility is not achieved

Taking into account the conclusions of the compatibility analyses, it was found that the following bands could be used by PWMS:

- 1452 MHz – 1477.5 MHz, in this band the following restrictions are applicable:
  - To protect FS operating in the frequency range1429 - 1452 MHz, the unwanted emissions defined in e.i.r.p of PWMS should not exceed -58 dBm in 200 kHz bandwidth
  - To protect FS/BSS operating above 1479.5 MHz, the unwanted emissions defined in e.i.r.p of PWMS in the frequency range 1479.5 – 1492 MHz should not exceed -58 dBm in 600 kHz bandwidth
  - The use of PWMS may be outdoor or indoor in this frequency range with a maximum radiated power of 50 mW (e.i.r.p)

Administration may need to consider the following when deploying PWMS on their territory:

- To protect FS operating in the band 1452 – 1479 MHz:
  - a separation distance of 15 km between the FS receiving station and the PWMS transmitter should be considered in a co-frequency situation. It is possible to reduce this separation distance in case of indoor usage of PWMS;
  - the PWMS emissions at the frequency used by a FS receiver should not exceed -48dBm in 200 kHz for PWMS operating at a distance from the considered FS receiver lower than the separation distance (15 km).
- To protect ground stations in the Aeronautical Telemetry Service operating in the frequency range 1429-1492 MHz, separation distance of 36 km between aeronautical receivers and PWMS transmitter is required. In case of PWMS deployment on the territory of a neighbouring country this separation distance should not be less than 36 km to the national border (see 5.342). To protect airborne stations, separation distances are assumed to be greater.

➢ 1494 MHz – 1517.4 MHz, in this band the following restrictions are applicable:

- To protect FS/Mobile/BSS operating below 1494 MHz, the unwanted emissions defined in e.i.r.p of PWMS in the frequency range 1479.5 – 1492 MHz MHz should not exceed -58 dBm in 600 kHz bandwidth
- The use of PWMS should be limited to indoor use in this frequency range with a maximum radiated power of 50 mW (e.i.r.p)
- To protect Fixed/Mobile/MSS operating above 1518 MHz, the unwanted emissions defined in e.i.r.p of PWMS in the frequency range 1518 – 1559 MHz should not exceed -48 dBm in 200 kHz bandwidth

Administration may need to consider the following when deploying PWMS on their territory:

- To protect FS operating in the band 1492 – 1518 MHz:
  - a separation distance of 15 km between the FS receiving station and the PWMS transmitter should be considered in a co-frequency situation;
  - the PWMS emissions at the frequency used by a FS receiver should not exceed -48dBm in 200 kHz for PWMS operating at a distance from the considered FS receiver lower than the separation distance (15 km).
- To protect ground stations in the Aeronautical Telemetry Service operating in the frequency range 1492-1535 MHz, separation distance of 28 km between aeronautical receivers and PWMS transmitter is required. In case of PWMS deployment on the territory of a neighbouring country this separation distance should not be less than 28 km to the national border (see 5.342). To protect airborne stations, separation distances are assumed to be greater.

These conclusions are valid for both analogue and digital cases. The compatibility studies between PWMS devices and Mobile Satellite service concluded that sharing is not feasible. Possible mitigation techniques (e.g. DAA) will be further investigated. When these results are available, this report should be revised or a complementary report will be developed.

For information, the SEAMCAT files used for the calculations for the study are available in a zip-file at the www.ero.dk (ERO Documentation Area) next to this Report.

Table of contents

List of Abbreviations

Abbreviation	Explanation
Band III	The frequency range 174 – 230 MHz
Band IV	The frequency range 470 – 614 MHz
Band V	The frequency range 614 – 862 MHz
BS	Broadcast Service
BSS	Broadcast Satellite Service
CEPT	European Conference of Postal and Telecommunications
CGC	Complementary Ground Component
CS	Central Station
DVS	Digital Video Sender
ECC	European Electronic Communications
EESS	Earth Exploration Satellite Service
e.i.r.p.	Equivalent isotropically radiated power
ETSI	European Telecommunications Standards Institute
FS	Fixed Service
FSS	Fixed Satellite Service
GMDSS	Global Monitoring Distress and Safety System
GOES	Geostationary Orbiting Earth Satellites
GSO	Geo Stationary Orbit
HD	High Definition
IM	Intermodulation
ITU	International Telecommunication Union
IEM	In Ear Monitor
L Band	Frequency range 1452 – 1559 MHz
LEO	Low Earth Orbit (for satellites)
LBT	Listen Before Talk
MCL	Minimum Coupling Loss
MSG	Meteosat Second Generation, a European geostationary meteorological satellite
MSS	Mobile Satellite Service
NJFA	NATO Joint Frequency Agreement
N/A	Non Applicable
OoB	Out Of Band emissions
OS	Out Station
P-MP	Point-to-Multipoint
P-P	Point-to-Point
PSD	Power Spectral Density
PWMS	Professional Wireless Microphone Systems
SAR	Search And Rescue
SARP	Search and Rescue Processors
SARR	Search and Rescue Repeaters
S-DAB	Satellite-Digital Audio Broadcasting
SEAMCAT	Spectrum Engineering Advanced Monte Carlo Analysis Tool
SESAR	Single European Sky Programme
SRD	Short Range Devices
SRDoc	System Reference Document (ETSI)
T-DAB	Terrestrial-Digital Audio Broadcasting
TPC	Transmitter Power Control
UWB	Ultra Wide Band

1 INTRODUCTION

Following a request from ETSI, WG FM requested WG SE to consider the possible deployment of Professional Wireless Microphone Systems (PWMS), in the bands:

- 1452 MHz to 1492 MHz,
- 1492 MHz to 1530 MHz,
- 1533 MHz to 1559 MHz.

In all of these bands, compatibility and sharing issues need to be assessed in order to identify the preferred sub-bands for PWMS. This report provides compatibility studies between PWMS and the services possibly affected by their deployment in the bands 1452-1492 MHz, 1492-1530 MHz, 1533-1559 MHz also considering the services in the adjacent bands (below 1452 MHz and above 1559 MHz).

2 DESCRIPTION OF PWMS SYSTEMS

The term PWMS (Professional Wireless Microphone Systems) includes all wireless equipment used at the front-end of all professional audio productions. PWMS are intended for use in the entertainment and installed sound industry by Professional Users involved in stage productions, public events, TV programme production, public and private broadcasters' installation in conference centres / rooms, city halls, musical and theatres, sport / event centres or other professional activities / installation. These can range from touring stage shows to sporting events, such as the Tour de France.

PWMS have traditionally been used in broadcasting bands III, IV and V, since 1957. The growth of theatrical and musical productions along with the requirements of "wireless" microphones in all forms of media, plus the growth of independent television and film production has resulted in the plethora of uses. Future PWMS microphone systems need to transmit high bandwidth HD sound. The typical audio quality of wireless audio transmission services is developing from 16 bit CD-quality towards HD-Sound with 28 to 32 bit resolution.

The main characteristics of PWMS systems are provided in ETSI TR 102 546 [1]. Section 2.2 provides the technical characteristics required to assess the compatibility between PWMS and other systems/services. A summary of the characteristics to be considered is given in Table 1 as proposed in ETSI TR 102 546.

Frequency band	Maximum mean power and mean power density	Duty cycle	Channel spacing (see note 1)	Remarks
1452 MHz to 1492 MHz	50 mW e.i.r.p.	No restriction	Up to 600 kHz	All user groups individual license required.
1492 MHz to 1530 MHz and 1533 MHz to 1559 MHz	50 mW e.i.r.p.	No restriction	Up to 600 kHz	All user groups individual license required. For indoor installations only.

Table 1: Extract of the PWMS characteristics given in ETSI TR 102 546 [1]

Two types of PWMS systems are considered:

- Radiomicrophone transmitters (either hand held, or used as body packs, where the transmitter unit will be hidden about the person of the artist, using a minimally-sized microphone affixed to their clothing). Wireless microphones, including the new High Definition microphones. These would be both hand held and body worn devices, used mainly indoors, but with some outdoor usage.
- In Ear Monitor transmitters using fixed installations.

It has to be noted that Audio Links are not considered in this report.

Considerations on the spectrum requirements for PWMS are given in Annex 1.

2.1 Current "operating mode" of PWMS

PMSE in the UHF band [2] may be authorized under general or individual licenses, depending on national licensing regime and on the category of PMSE. However, even in the case of general license, the devices are to the large extent used by professional users, which enable to ensure the coexistence with broadcasting service. This permits to grant a high quality of usage of the UHF band, and usually to avoid interferences to primary services.

PWMS cannot use occupied channels in the neighbourhood of a transmitter as this would also interfere with their systems. Therefore, there is an inherent necessity on the part of the PWMS operator to avoid co-channel interference scenarios for their own protection.

2.2 Technical parameters for PWMS considered for compatibility analyses (1452-1530 MHz and 1533-1559 MHz)

Table 2 provides characteristics for PWMS transmitter/receiver.

Parameter	Value	Comments
Maximum radiated power	50 mW e.i.r.p.	
Antenna beam shape/gain	Below 1525 MHz: Omni directional	Body worn antenna. Dipole: 2.14dBi max.
	Above 1525 MHz: Directional	Fixed antenna (IEM). Max antenna gain 8 dB
Minimum wanted signal level	-80dBm at 50 Ω	
Communication mode	Continuous carrier, 100% duty cycle	

Table 2: Characteristics of PWMS given in ETSI TR 102 546 [1]

The spectrum mask given in the following section are extracted from EN 300 422 [3].

Initially only up to 200 kHz analogue will be deployed, then, it is expected that digital systems will be deployed with bandwidth extending from 200 kHz to 600 kHz.

For compatibility analyses purpose, two cases should be considered:

- 200 kHz worst case between analogue and digital masks and
- 600 kHz digital.

2.2.1 Analogue PWMS with bandwidth up to 200 kHz

Figure 1 provides the emissions mask for transmitter up to 200 kHz bandwidth [3].

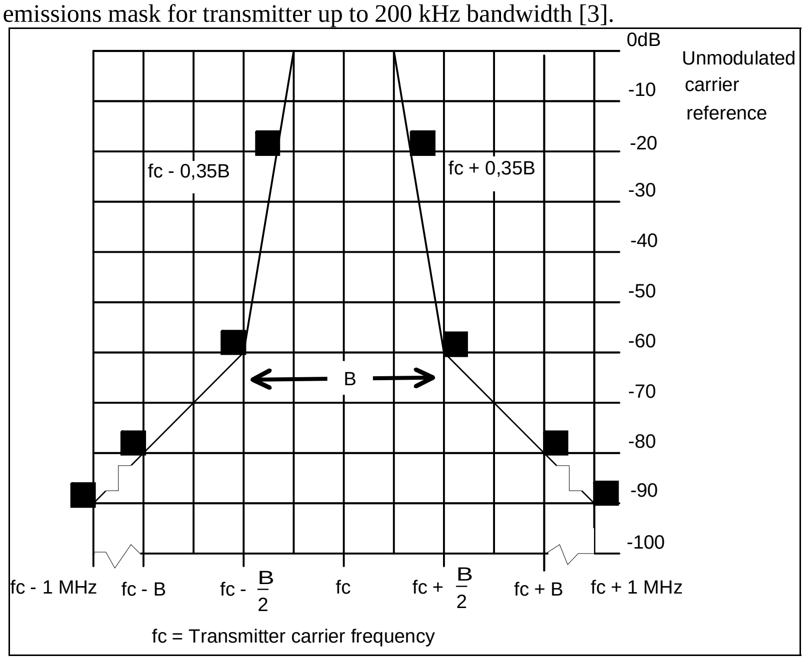


Figure 1: PWMS (except audio links) Transmitter Emission Mask – Bandwidth up to 200 kHz [3]

2.2.2 Digital Systems with bandwidth 200 kHz – 400 kHz – 600 kHz

Figure 2 provides the emissions mask for transmitter of 600 kHz bandwidth as given in ETSI EN 300 422 [3].

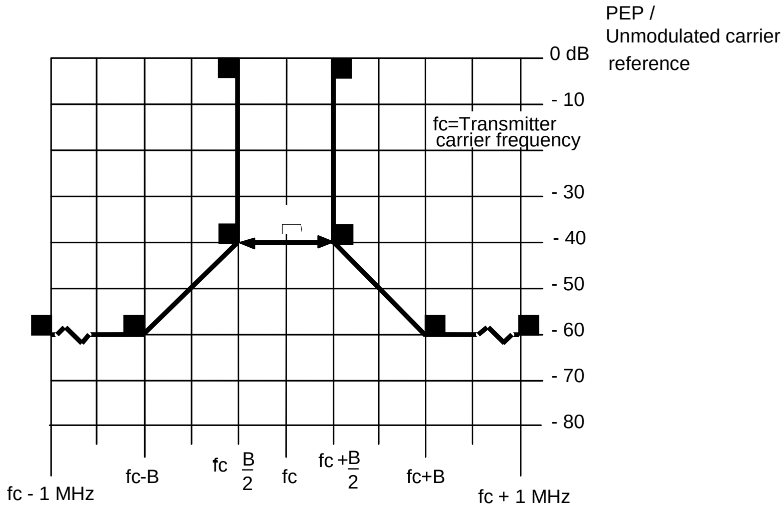


Figure 2: PWMS (except audio links) Transmitter Emission Mask – normalised to channel bandwidth B [3]

2.2.3 Antenna pattern

Below 1525 MHz: only body worn antennas are considered for PWMS, the corresponding antenna pattern is omni directional linear polarized dipole gain 2.14 dBi max (see Figure 3 below).

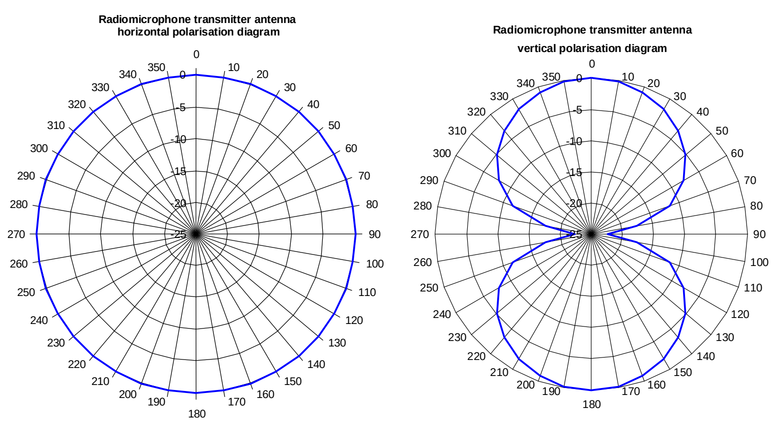


Figure 3: PWMS Body Worn Antenna Pattern below 1525 MHz

These systems are assumed to be 1.5 m above ground for hand-held and 1m for body-worn devices.

Above 1525 MHz: only fixed antennas In Ear Monitor (IEM) are considered.

The usual configuration for IEM transmitter antennas is to mount them high above the stage at a height of at least 6 meters. They are then angled down towards the stage at approximately 45º (see Figure 4).

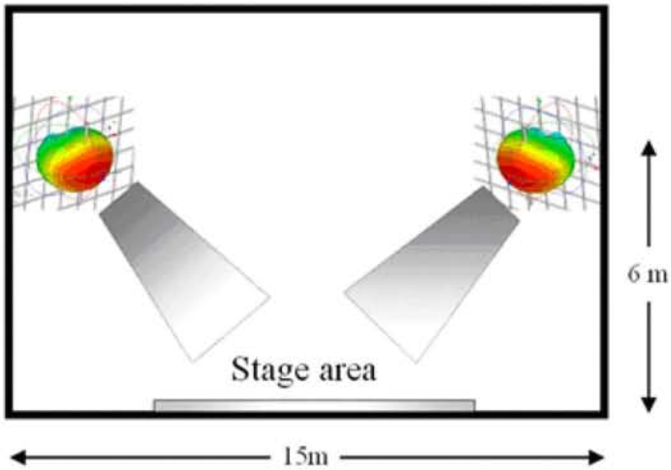


Figure 4: IEM Configurations

This has the multiple benefits of keeping the antennas out of sight of the audience, keeping the propagation path to the performer relatively un-obstructed and reducing interference to nearby systems. The latter comes about because propagation in a horizontal direction is via a combination of the side lobes of the antenna and scatter from the stage.
Figure 5 provides the horizontal and vertical pattern of IEM antennas.

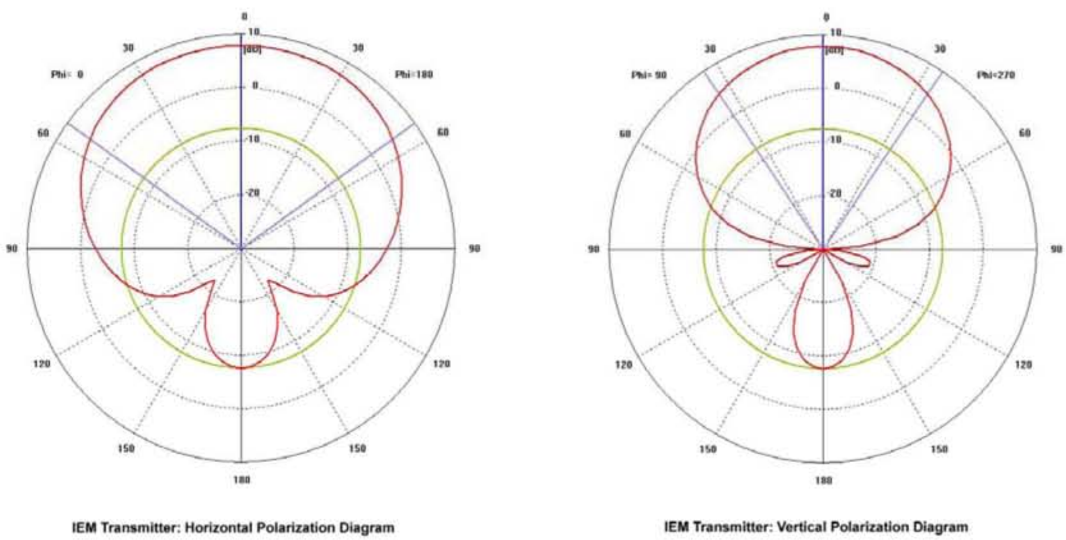


Figure 5: PWMS IEM Antenna Pattern above 1525 MHz

It is estimated that this attenuates the IEM transmitter signal by around 6dB in the side lobe.

3 CONSIDERATION ON THE COMPATIBILITY STUDIES

3.1 General considerations

The report investigated the compatibility between PWMS and other services/systems in co-frequency cases and non co-frequency cases.

For co-frequency cases, the required separation distances are investigated.

Two non co-frequency cases, two cases are investigated:

- First cases: “adjacent bands case”, where the victim is operating in a given band and the PWMS systems are operating in an adjacent band in order to determine the size of the guard band between the edge of the band used by the victim and the edge of the first channel possibly available for PWMS systems (figure 10 provides an example of such cases).

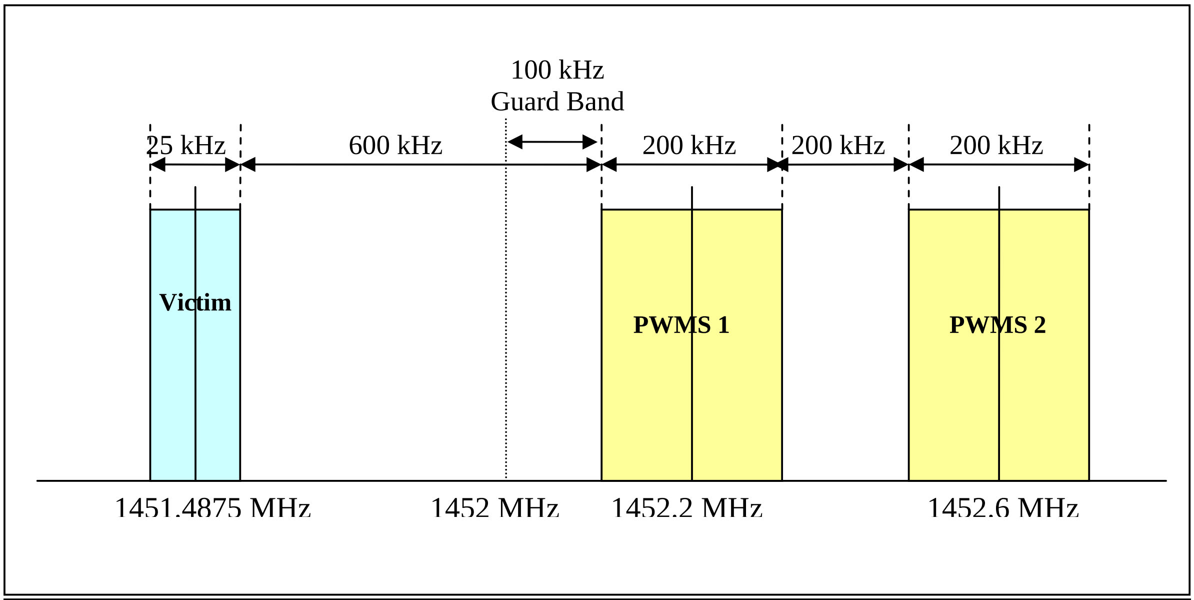


Figure 6: Example of adjacent bands cases 200 kHz PWMS operating above 1452 MHz and 25 kHz FS operating in the frequency range below 1452 MHz

- Second cases: “off channel case”, where the victim and the PWMS systems are operating in the same band, determining the frequency offset between the edge of the channel of the possible victim and the edge of the channel of the first adjacent possibly available for PWMS system.

The following table provide an overview of the cases to be considered in the compatibility analyses and the corresponding assumptions for PWMS deployment.

Note: considering the conclusions given in section 8.5 the impact of unwanted emissions falling above 1559 MHz was not considered.

Band (MHz)	Service /Applications					Compatibility analyses
1429 – 1452	FIXED	MOBILE (except Aeronautical Mobile)	Aeronautical telemetry (**5.342**)			Non co-frequency case limited to "adjacent bands case" Outdoor Body Antenna / IEM
1452-1492	BS 1452-1479.5 MHz	BSS 1479.5 – 1492 MHz	Fixed (secondary)	Mobile (except Aeronautical Mobile) (secondary)	Aeronautical telemetry (**5.342**)	Co-frequency case Adjacent cases Outdoor Body worn antenna / IEM
1492-1518	FIXED	MOBILE (except Aeronautical Mobile)	Aeronautical telemetry (**5.342**)			Co-frequency case Adjacent cases Indoor Body worn antenna / IEM
1518-1525	FIXED	MOBILE (except Aeronautical Mobile)	MSS (s-E)	Aeronautical telemetry (**5.342**)		Co-frequency case Adjacent cases Indoor Body worn antenna / IEM
1525-1530	FIXED	SPACE OPERATION (s-E)	MSS (s-E) **(5.351)**	Aeronautical telemetry (**5.342**)		Co-frequency case Adjacent cases Indoor IEM
1533-1535	MSS (s-E) **5.351.A 5.353A)**	SPACE OPERATION (s-E)	Aeronautical telemetry (**5.342**)	Mobile (except Aeronautical Mobile)	Eess	Co-frequency case Adjacent cases Indoor IEM
1535-1559	MSS (s-E) **5.351° 5.353° 5.357°**					Co-frequency case Adjacent cases Indoor IEM

Table 3: List of compatibility analyses [4]

5.342 *Additional allocation:* in Armenia, Azerbaijan, Belarus, Bulgaria, the Russian Federation, Uzbekistan, Kyrgystan and Ukraine, the band 1 429-1 535 MHz is also allocated to the aeronautical mobile service on a primary basis exclusively for the purposes of aeronautical telemetry within the national territory. As of 1 April 2007, the use of the band 1 452-1 492 MHz is subject to agreement between the administrations concerned. (WRC-2000).

5.351A For the use of the bands 1 525-1 544 MHz, 1 545-1 559 MHz, 1 610-1 626.5 MHz, 1 626.5-1 645.5 MHz, 1 646.5-1 660.5 MHz, 1 980-2 010 MHz, 2 170-2 200 MHz, 2 483.5-2 500 MHz, 2 500-2 520 MHz and 2 670-2 690 MHz by the mobile-satellite service, see Resolutions **212 (Rev.WRC-97)** and **225 (WRC-2000)**. (WRC-2000).

5.353A In applying the procedures of Section II of Article **9** to the mobile-satellite service in the bands 1 530-1 544 MHz and 1 626.5-1 645.5 MHz, priority shall be given to accommodating the spectrum requirements for distress, urgency and safety communications of the Global Maritime Distress and Safety System (GMDSS). Maritime mobile-satellite distress, urgency and safety communications shall have priority access and immediate availability over all other mobile satellite communications operating within a network. Mobile-satellite systems shall not cause unacceptable interference to, or claim protection from, distress, urgency and safety communications of the GMDSS. Account shall be taken of the priority of safety-related communications in the other mobile-satellite services. (The provisions of Resolution **222 (WRC-2000)** shall apply.) (WRC-2000).

5.357A In applying the procedures of Section II of Article **9** to the mobile-satellite service in the bands 1 545-1 555 MHz and 1 646.5-1 656.5 MHz, priority shall be given to accommodating the spectrum requirements of the aeronautical mobile-satellite the service providing transmission of messages with priority 1 to 6 in Article **44**. Aeronautical mobile-satellithe(R) service communications with priority 1 to 6 in Article **44** shall have priority access and immediate availability, by pre-emption if necessary, over all other mobile-satellite communications operating within a network. Mobile-satellite systems shall not cause unacceptable interference to, or claim protection from, aeronautical mobile-satethete (R) service communications with priority 1 to 6 in Article **44**. Account shall be taken of the priority of safety-related communications in the other mobile-satellite services. (The provisions of Resolution **222 (WRC-2000)** shall apply.) (WRC-2000).

It has to be noted that WG FM is considering the feasibility of introduction of CGC in the mobile satellite service bands 1626.5-1645.5 and 1646.5-1660.5 MHz and 1525-1544 and 1545-1559 MHz. This compatibility study at 1525-1544 MHz and 1545-1559 MHz between CGC and PWMS was not considered when developing this report.

The following sections provide general consideration on the use of some of the services considered in the compatibility studies. Additional information may also be found in each of the relevant section.

3.1.1 General considerations on the use of the 1.5 GHz band by the FS

ECC Report 03 [5] gives the general trends for the use of the FS links within CEPT. For the 1.5 GHz band, 1350-2690 MHz, the overall CEPT spectrum policy foresees optimisation of this band for the use by mobile and other radiocommunication services, which for line-of-sight and similar operational limitations may not be accommodated in the bands higher than about 3 GHz.
However, many CEPT administrations stressed the need to continue FS use in parts of this band and the availability of suitable channel arrangements (Recommendation T/R 13-01 [6]) to allow the long-term development of fixed services side-by-side with mobile and other services in this frequency range. The annex 1 of this report [6] gives the different national use of this band by FS.

Beside the civil FS use, the 1350-2690 MHz frequency range, is also extensively used for tactical fixed links within NATO as well as in non-NATO countries. Within the NATO Joint Frequency Agreement (NJFA) particular frequency bands in the ra–ge 1350 - 2670 MHz are identified for the use of tactical radio relay systems. As a result of the WARC-92 decisions a transition of the tactical radio relay applications to harmonized sub-bands above 2000 MHz is envisaged. With regard to the military usage in the bands considered in this report, representative from NATO indicated that there was no NATO system to be protected from PWMS in the bands under considerations. Therefore, if there are national systems to be protected, they are covered in the report only if administration expressed concerns on the protection of a given service.

3.1.2 General considerations on the use of the 1.5 GHz band by the MS

According to EU15A, the use of the bands considered in this report by the Mobile Service is limited to tactical radio relay applications. Therefore, the considerations given in section 3.1.1 with regard to the Fixed Service are applicable to the Mobile Servic.

3.1.3 General considerations on the use of the 1.5 GHz band by the MSS

ECC/DEC/(04)09 [7] has designated the band 1518-1525MHz to MSS use. Many other ECC Decisions the bands 1525-1559 MHz are designated by CEPT to MSS [8] [9].

The MSS bands covered in this report are used for many different MSS applications. Two of the MSS applications relate to provision of safety and distress communications for the maritime and aeronautical communities. Under ITU regulations footnotes 5.353a and 5.357a, the Global Maritime Distress and Safety System (GMDSS) has regulatory protection for its transmissions, anthehe AMS(R)S service has requirements for access to suitable spectrum for its services.

While indoors PWMS is unlikely to be geographically local to maritime services, the use of PWMS outdoors may not be. If used outdoors these transmissions could interfere with GMDSS and maritime services (if local to a coastal area) or over flying aeronautical aircraft utheg the AMS(R)S services. The European Space Agency and the EC within the Single European Sky Programme (SESAR) is using the use of satellite communications for aeronautical services.

3.1.4 General considerations on the use of the 1.5 GHz band by the BS

The frequency band 1452-1479.5 MHz is planned for terrestrial mobile multimedia services through the Maastricht 2002 Special Arrangement, as revised in Constanta 2007 (MA02revCO07) [10]. The basis for the entries in the frequency plan is the use of T-DAB. However, through the spectrum mask concept and the aggregation of contiguous T-DAB frequency blocks, also other systems can be implemented, as long as these systems do not cause more interference nor claim more protection. Systems that may be considered are e.g. T-DMB or future developments of DVB-H. The availability of this frequency band for other services than terrestrial mobile multimedia services, are therefore dependant on the implementation of such services, which may vary between countriEurope.

3.1.5 General considerations on the use of the 1.5 GHz band by the Aeronautical Telemetry

According to footnote 5.342 the band 1429-1535 MHz could be used on primary basis in some countries. Due to primary status and nature of aeronautical telemetry regulations in those countries there are no means to limit frequency usage for such systems. Therefore, aeronautical telemetry can switch to any carrier anytime without noticing civilian regulatory body. This makes the band 1429-1535 MHz virtually occupied by aeronautical telemetry. In such case there is no possibility to ascertain adjacent channel PWMS operation in the band 1452-1492 MHz. Any PWMS carrier in the band 1452-1535 MHz will have corresponding aeronautical telemetry co-channel receiver and needed separation will be acquired from co-channel scenario. Adjacent channel operation could be investigated only in the band 1535-1559 MHz where aeronautical telemetry has no allocation.

3.2 Assumptions used in the compatibility studies

3.2.1 PWMS Characteristics (see also section 2)

Two kinds of devices PWMS except audio devices have to be considered with:

- 200 kHz bandwidth
- 600 kHz bandwidth

When comparing the emissions mask for Analogue PWMS with the one given for Digital PWMS it appeared that the digital is the worst case, therefore only this case is considered.

With regard to the antenna for PWMS, ETSI [1] proposed that the body antenna case was considered first for frequency below 1525 MHz (see Figure 3) and that the IEM antenna case was considered for frequency above 1525 MHz. However, it was agreed to considered the IEM case also for frequency below 1525 MHz.

The deployment of PWMS is assumed to be outdoor for frequency below 1492 MHz and indoor for frequency above 1492 MHz.

3.2.2 Propagation model used in the compatibility studies

Measurements have been conducted in order to identify the propagation model corresponding to the PWMS situation (see Annex 3). The results did not allow identifying “the” propagation to be used in order to assess compatibility with PWMS and other Services/Systems. Therefore, several propagation models are considered in the compatibility analyses.

3.2.3 Absorption in walls

The SRDoc [1] considered a range of values based of a campaign of measurements which are provided below:

Wall type / material	Absorption @1450MHz
Lime sandstone 24cm	34 dB
Lime sandstone 17cm	29 dB
Ytong 36.5cm	23 dB
High hole brick 24cm	19 dB
Reinforced concrete 16cm	13 dB
Lightweight concrete 11.5cm	9 dB
ThermoPlane	6 dB

Table 4: Wall Attenuation values

The measurements provided in Annex 4 have confirmed the range of value for the wall loss attenuation. The value of 10 dB is considered for the compatibility analyses.

4 COMPATIBILITY STUDIES IN THE BAND 1429-1452 MHz

This section considers the possible effect of the unwanted emissions of PWMS falling below 1452 MHz.

4.1 Compatibility between PWMS and Service

4.1.1 Fixed Service Characteristics

The ITU-R Recommendation F.1334 [11] on the Protection criteria for systems in the fixed service sharing the same frequency bands in the 1 to 3 GHz range with the land mobile service gives some indication about characteristics and protection criteria, in particular a receiver noise floor level in the order of -140dBW/MHz with a protection of I/N= -20dB for Fixed Service operating with a primary status.

Characteristics of P-P FS links are described in the relevant ETSI documents, EN 300 630 [12] and EN 300 631 for antenna gains [13].

Different channel bandwidths are available in the range 25 kHz-3.5 MHz mostly used for narrow bandwidth (<1 MHz).

The channel plan given in Recommendation T/R 13-01 is considered [6]. The closest channel from 1542 MHz will be: 1451.4875 MHz.

The noise density after the antenna is -140dBm/kHz.

Typical antenna gain is about 13dBi but may be higher. Therefore 2 types of antenna are considered hereafter: a Yagi antenna with 13 dBi gain, and a dish antenna with a 30 dBi gain. Figure 7 gives the antenna radiation patterns for both antenna derived from ITU-R Rec. F.1245 [14]. It can be seen that the gains for angle greater than 45° are approximately -9 dBi for a dish antenna and -4 dBi for a Yagi antenna. Therefore the mainlobe to sidelobe attenuations are 39 dB for a dish antenna and 17 for a Yagi antenna.

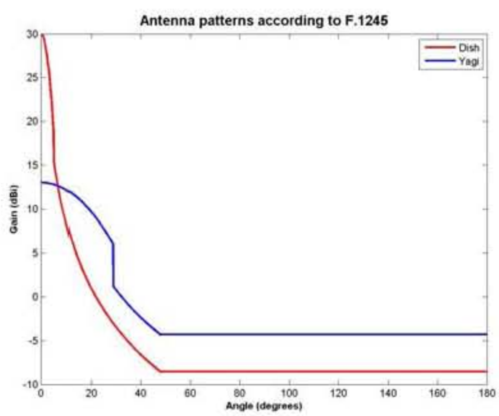


Figure 7: FS antenna patterns derived from ITU-R Rec. F.1245

FS deployment:
Fixed services are mainly located in rural areas, with a typical antenna height of 20m. However, as described in ERC Report 10 [15], Radio relay systems in this band are also used in urban areas and are typically mounted on a roof of a building.

4.1.2 PWMS Characteristics

The following table provides a summary of the assumptions considered for PWMS (see also section 3.2.1.).

Parameter	Value	Comments
Maximum radiated power	50 mW e.i.r.p.	
Bandwidth	200 kHz – 600 kHz	
Emission mask	Digital	See Figure 2
Antenna beam shape/gain	Omni directional	Body worn antenna. Dipole: 2.14dBi max (see Figure 3)
	Directional	Fixed antenna (IEM). Max antenna gain 8 dB see Figure 5)
Antenna height	2.5 m	Body worn antenna.
	7 m	IEM
Deployment	Outdoor	
Operating Frequencies	1542.2 MHz and 1542.6 MHz	200 kHz case (see Figure 6 where a guard band of 100 MHz is assumed between 1542 MHz and the edge of the first PWMS channel)

Table 5: PWMS Characteristics

It is important to note that since there is a guard band of 500 MHz below 1452 MHz within the FS band, the frequency offset between the edge of the first FS channel and the center frequency of the PWMS system will always be larger than 500 MHz + B/2 (where B is the bandwidth of the PWMS system). This results in frequency offset values of 600 MHz for the 200 kHz case and 800 MHz for the 600 kHz. This implies, considering the emissions mask of PWMS systems, that the rejection will always be 60dB between the e.i.r.p of the PWMS system (17dBm) and the level falling into the FS receiver bandwidth.

Then, the level of the unwanted emissions of the PWMS systems to be considered for the calculations will be for the 200 kHz:

$$17\text{dBm} - 60\text{ dB} = -43\text{ dBm in } 200\text{ kHz}$$

And for the 600 kHz case:

$$17\text{dBm} - 60\text{ dB} = -43\text{ dBm in } 600\text{ kHz or about } -48\text{ dBm in } 200\text{ kHz}$$

It can then be concluded that the results achieved considering the 200 kHz PWMS case and a given level of rejection will be worse than those achieved considering the 600 kHz case for the same level of rejection.

The level received by the FS receiver would then be calculated taking into account the correction resulting from the size of the FS bandwidth (i.e. 10 x log (25/200) = -9dB in case of a 25 kHz channel).

4.1.3 Simulations

Simulations were conducted using SEAMCAT (www.ero.dk/seamcat). For the purpose of these simulations the density of PWMS operating on a given channel is assumed to be 0.1 Tx per km^2. This number seems realistic taking into account the results of the measurements (see Annex 4) and the corresponding possible re-use distance of a given frequency for PWMS systems.

For the rural environment case, the FS antenna is assumed to be deployed outside from a city, and the PWMS are assumed to be deployed within the city, therefore, a separation distance of 1km is considered between the FS receiver and the first PWMS transmitter. In order to model a deployment within a city (i.e. not spread everywhere around the FS receiver), 10 PWMS transmitters are deployed in angles ranging from 0 degree to 90 degrees seen from the FS receiver station (see Figure 8).

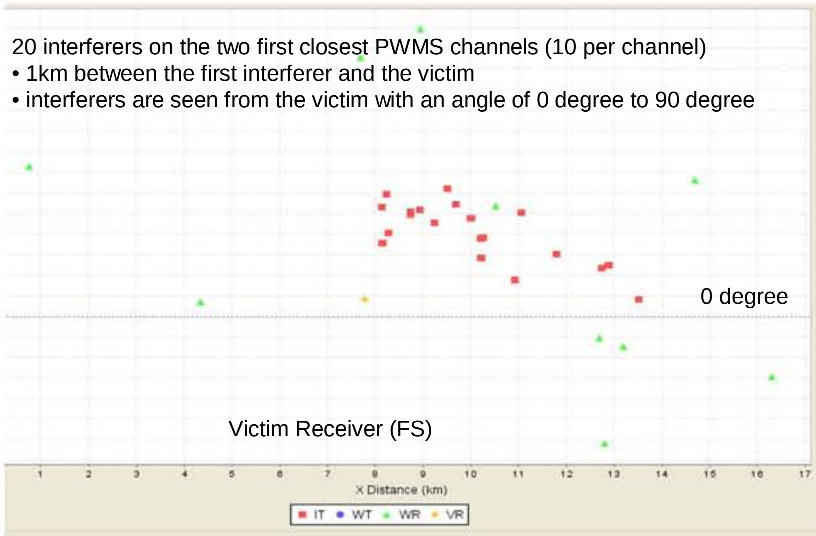


Figure 8: PWMS deployment around a FS antenna in rural environment

For the urban environment case, 10 PWMS transmitters are deployed without any restriction around the FS antenna.

4.1.4 Results of simulations

Table 6 provides results of simulation for the 200 kHz PWMS system and 25 kHz FS for a rejection of 60 dB.

FS antenna	13 dB Yagi		30 dB Dish	
PWMS Antenna	Body antenna	IEM	Body antenna	IEM
Rural	18 %	24 %	17.5 %	22 %
Urban	1 %	1.5 %	1 %	1.5 %

Table 6: 25 kHz FS / 200 kHz PWMS – 60dB rejection

Considering the results above, additional simulations were conducted considering a level of rejection of 70dB for the emissions falling into the FS receiver.

FS antenna	13 dB Yagi		30 dB Dish	
PWMS Antenna	Body antenna	IEM	Body antenna	IEM
Rural	1.5 %	3 %	1.5 %	8 %
Urban	0.5 %	1 %	0.5 %	1.5 %

Table 7: 25 kHz FS / 200 kHz PWMS – 70dB rejection

Finally, simulations were conducted for the 30dB dish antenna IEM case and a rejection of 75dB, leading to a probability of 4 %.

Noting that:

- for the considered frequency offsets, the level of emissions resulting from PWMS is flat over the 25 kHz of the FS receiver (constant 60dB rejection)
- for the considered frequency offsets, the level of emissions resulting from PWMS is flat over larger FS receiver bandwidth (i.e. for example 2000 kHz)
- the ratio between the calculated levels of unwanted emissions in the 2000 kHz FS and the level of unwanted emissions in the 25 kHz FS will be equal to the ratio of the bandwidths
- the respective Noise (N) use as a reference to calculate the probability (I/N criterion) are also linked by the same ratio of bandwidths,

It may be concluded for other FS receivers bandwidths that the results will be similar to those given in Tables 6 and 7.

The results provided in table 7 above are calculated for a given rejection and are relative to the power of the PWMS system. Therefore, as indicated in section 4.1.2, for the 600 kHz case, the corresponding absolute level in dBm in 200 kHz is 5dB lower

4.2 Compatibility between PWMS and Mobile Service

Considering section 3.12, the considerations given in section 4.1 with regard to the Fixed Service are applicable.

4.3 Compatibility between PWMS and Aeronautical service

In the frequency range 1452-1535 MHz, separation distances will be calculated to protect the Aeronautical Telemetry Service (see section 5.5 and 6.3). The application of these separation distances will ensure the protection of Aeronautical Telemetry systems operating in1429-1452 MHz.

4.4 Conclusions for the protection of systems operating below 1452 MHz

The following limits should be considered for the protection of Fixed Service operating below 1452 MHz

- Body worn antenna: 70dB rejection or 17-70 = -53dBm in 200 kHz applicable for 200 kHz to 600 kHz channel spacing
- IEM: 75dB rejection or 17-75 = -58dBm in 200 kHz applicable for 200 kHz to 600 kHz channel spacing

Therefore a limit of -58dBm in 200 kHz should be considered.

The Aeronautical service will be protected by the application of separation distances calculated for the co-channel case (see section 5).

These conclusions are valid for both analogue and digital cases and for outdoor deployment.

5 COMPATIBILITY STUDIES IN THE BAND 1452-1492 MHz

5.1 Compatibility between PWMS and Fixed Service

5.1.1 Fixed Service Characteristics

The same characteristics as in section 4.1.1 are considered.

In the band 1492-510 MHz, the Fixed Service has a secondary status, therefore, the I/N is taken equal to -10dB.

In addition, according to Recommendation T/R 13-01 [6], this part of the spectrum corresponds to center gap of the frequency plan for the band 1350-1375 MHz paired with 1492-1517 MHz.

5.1.2 PWMS Characteristics

The characteristics of PWMS given in section 4.1.2 are considered.

5.1.3 Simulations

In this band, all cases identified in section 3.1 should be considered.

- Determination of separation distance between PWMS and FS operating on the same frequency (MCL calculations and SEAMCAT simulations)
- “adjacent bands case”, where the victim is operating in 1452-1492 MHz and the PWMS systems are operating above 1492 MHz, in order to determine the size of the guard band between the edge of the band used by the victim and the edge of the first channel possibly available for PWMS systems (SEAMCAT calculations using the same scenarios as in 4.1.3)

- "off channel case", where the victim and the PWMS systems are operating in the band 1452-1492 MHz, determining the frequency offset between the edge of the channel of the victim and the edge of the channel of the first adjacent possibly available for PWMS system (SEAMCAT calculations using the same scenarios as in 4.1.3)

5.1.4 Results of simulations

Co-frequency studies (protection distances to protect FS operating in the band 1452-1492 MHz from PWMS operating in the same band)

Table below shows some MCL calculations with a 200 kHz PWMS body antenna as interferer and a FS victim with a yagi antenna at various bandwidths.
Resulting protection distances are calculated using a dual slope free space model (20 log for distances up to 5 km and 40 log above) and an extended Hata model for rural environment (with a PWMS height of 2m and a FS height of 20m).

Emission part: PWMS	Value	Units	**PWMS**
Bandwidth	**200**	kHz	200
Tx out, eirp	**17**	dBm	17
Tx Out eirp per kHz	**-6**	dBm/kHz	-6
effect of TPC (dB)	**0**	dB	0
OoB Attenuation	**na**	dB	0
Tilt attenuation	**na**	dB	0
Net Tx Out eirp		dBm/kHz	**-6**
Antenna Gain	**2**	dBi	
Frequency (GHz)	**1.50**	GHz	

Reception part: FS									
Receiver bandwidth		kHz	25	75	250	500	1000	2000	3500
Antenna height	**20**	m	20	20	20	20	20	20	20
Criterion I/N	**-10**	dB	-10	-10	-10	-10	-10	-10	-10
Rx noise floor level (-110dBm/MHz)	**-140**	dBm/kHz	-140	-140	-140	-140	-140	-140	-140
		dBm	-126	-121	-116	-113	-110	-107	-105
Max allowable interfering power at receiver after the antenna		dBm	-136	-131	-126	-123	-120	-117	-115
Antenna gain	**13**	dBi	13	13	13	13	13	13	13
Bandwidth correction factor		dB	-9	-4	0	0	0	0	0

Wall loss	**0**	dB	0	0	0	0	0	0	0
MAIN LOBE PWMS - MAIN LOBE FS									
Allowable Interfering power level at receiver (before the antenna)		dBm	-140	-140	-139	-136	-133	-130	-128
Required path attenuation		dB	157	157	156	153	150	147	145
Separation distance PWMS->FS									
LoS limitation (optical visibility)		km	18.47	18.47	18.47	18.47	18.47	18.47	18.47
FS losses up to 5 km		dB	110	110	110	110	110	110	110
Free space C		km	74.97	74.97	70.90	59.62	50.13	42.16	36.65
Free space model : min (FS, LoS)		**km**	**18.47**	**18.47**	**18.47**	**18.47**	**18.47**	**18.47**	**18.47**
Hata model rural		**km**	**29**	**29**	**28**	**24**	**21**	**17**	**15**
MAIN LOBE PWMS - SIDE LOBE FS									
Relative sidelobe to mainlobe attenuation	**17**	dB	17	17	17	17	17	17	17
Allowable Interfering power level at receiver (before the antenna)		dBm	-123	-123	-122	-119	-116	-113	-111
Required path attenuation		dB	140	140	139	136	133	130	128
Free space attenuation		km	28.18	28.18	26.65	22.41	18.84	15.84	13.78
Free space model : min (FS, LoS)		**km**	**18.47**	**18.47**	**18.47**	**18.47**	**18.47**	**15.84**	**13.78**
Hata model rural		**km**	**11.0**	**11.0**	**10.0**	**8.0**	**7.0**	**5.5**	**5.0**

Table 8: Protection distances between a 200 kHz body antenna and a fixed service (Yagi)

Considering the results of the rural extended Hata model, the distance separation ranges from 29 km (main lobe PWMS to main lobe FS, 25 kHz bandwidth) to 5 km (main lobe PWMS to side lobe FS, 3500 kHz bandwidth).

Replacing the Yagi antenna (maximum antenna gain 13dBi) by a dish (maximum antenna gain 30dBi)), the required path attenuation should be increased by 17 dB for the main lobe PWMS to main lobe FS and decreased by 4 dB for the main lobe PWMS to side lobe FS (-9dB in the side lobes of the dish and -5dB in the side lobes of the Yagi antenna).

For the 600 kHz, noting the difference of 5 dB in spectral density, the distances will be shorter than those given in Table 8 for cases where the victim bandwidth is smaller than 600 kHz and identical for cases where the victim bandwidth is larger than 600 kHz.

For the IEM case, the rejection in the side lobes will result in 6 dB less required attenuation (due to the IEM pointing direction: 45 degree). In the victim side lobe, for the 25 kHz FS case (worst case according to Table 8); this will result in a separation distance of 15 km.

The following separation distances are then necessary:
Body worn antenna: 11 km
IEM: 15 km

Off channel/Adjacent case

The results provided in this section are applicable to FS operating in the band 1452-1492 MHz from PWMS in the same band but not on the same channel (note: when considering this section the results on BSS given in section 5.4 need to be considered since they result in a limitation of the spectrum possibly usable for PWMS).

The results will be similar to those given in the section 4.1.4 taking into account the difference of I/N (-10dB instead of-20dB). Then, the results achieved for a rejection of 70dB will be achieved for a rejection of 60 dB in the body worn antenna case while those achieved for a rejection of 75dB are achieved for a rejection of 65 dB. It can then be concluded that:

- A rejection of 60 dB is needed for body antenna, corresponding to a level of 17-60dB=-43dBm in 200 kHz
- A rejection of 65dB is needed for IEM, corresponding to a level of: 17-65dB=-48dBm in 200 kHz

5.1.5 Conclusion for the FS in the 1452-1492 MHz

Co-channel case:
15 km is required between PWMS and FS stations.

In order to protect FS receiver, the following level should be met at the frequency received by the FS station:

- A rejection of 65dB is needed corresponding to a level of: 17-65dB=-48dBm in 200 kHz

These conclusions are applicable for outdoor deployment for both IEM and body worn antenna.

5.2 Compatibility between PWMS and Mobile Service

The Mobile Service is also with a secondary service status in this band according to ERC Report 25 [4]. In addition, according to EU15A, the use of the bands considered in this report by the Mobile Service is limited to tactical radio relay applications. Therefore, the considerations given in section 3.1.1and 5.1 with regard to the Fixed Service are applicable.

5.3 Compatibility between PWMS devices and Broadcasting service (1452-1479.5 MHz)

The 1452-1479.5 MHz band (27.5 MHz) has been planned in Europe by two CEPT T-DAB Planning Meetings. The resulting frequency Plan as associated with the MA02revCO07 Special Agreement uses 16 x 1.7 MHz T-DAB blocks to provide 1-3 nation-wide coverage(s) per country for mobile reception.

The CEPT supplemented the MA02 revCO07 Special Arrangement with additional regulatory and technical provisions to add flexibility to specifically allow among others for other reception modes for T-DAB and the introduction of radio-communication services other than T-DAB through the application of an interference envelope concept similar to that in the GE06 Agreement.

5.3.1 Characteristics for T-DAB

For the compatibility studies it is appropriate to consider the following T-DAB parameters as extracted from MA02 revCO07 Special arrangement:

	T-DAB portable outdoor or mobile reception at 1.5 GHz
Bandwidth	1.536 MHz
Minimum equivalent field strength (dB(μV/m))	46
Location percentage correction factor (50% to 99%)[1]	+13
Antenna height gain correction (dB)	+10
Minimum median field strength for planning (dB(μV/m)) at an antenna height of 10m	69

NOTE 1: The required location percentage for T-DAB services is 99%. Taking into account an estimated standard deviation of 5.5 dB for a location variation of a T-DAB signal, the location correction factor is 2.33 x 5.5 = 13 dB.

Table 9: Characteristics of T-DAB

The maximum allowable field strength of an interference signal (FS_I) to protect the minimum wanted field strength of a T-DAB signal ($FS_{T\text{-}DAB}$) is calculated as follows:

Maximum allowable –S_I =–($FS_{T\text{-}DAB}$ - PR - 18) dB(μV/m)

where

$FS_{T\text{-}DAB}$ = 69 dB(μV/m)

PR is the Protection Ratio to protect T-DAB signals from PMWS.

18 dB is the propagation correction factor to protect T-DAB signals for 99% locations against unwanted signals ($2.33 \times 5.5 \times \sqrt{2} = 18$ dB). The field strength values for wanted and unwanted signals are assumed to be uncorrelated.

NOTE: It is assumed that receiving antenna directivity or polarisation discrimination are not considered as both wanted and unwanted signals use omnidirectional antennas.

Video link		
Service identifier	**Field strength to be protected in dB(μV/m)**	**Transmit antenna height (m)**
YB	69.0	10.0

Δ f (MHz)	-8.0	-7.5	-7.0	-6.5	-6.0	-5.5	-5.0	-4.5	-4.0	-3.5	-3.0
PR (dB)	-42.0	-23.5	-10.0	-3.0	-2.0	-3.0	-24.0	-21.0	-23.0	-31.0	-31.5
Δ f (MHz)	-2.5	-2.0	-1.5	-1.0	-0.9	-0.8	-0.7	-0.6	0.0	0.6	0.7
PR (dB)	-30.0	-28.5	-25.0	-19.5	-17.5	-11.0	-7.0	-1.5	-1.5	-4.0	-5.5
Δ f (MHz)	0.8	0.9	1.0	2.0	3.0						
PR (dB)	-13.5	-17.0	-20.0	-33.0	-47.5						

Table 10: Protection Ratio to protect T-DAB from Video Link in MA02RevCo07

5.3.2 Considerations on the protection of T-DAB (1452-1479.5 MHz)

Currently, PWMS applications of all types co-exist in an acceptable manner with T-DAB services in UHF. There administrations may consider the same arrangement in the T-DAB segment of L Band. Other administrations may consider taking appropriate measure such as:

- calculating separation distances to protect T-DAB from PWMS systems
- calculating the required guard band

using the material provided in section 5.2.1.

It should also be noted that, following the revision of the Maastricht, 2002, Special Arrangement at the Constanța, 2007 (MA02revCO07 [119), allows for flexible use by mobile multimedia technologies. Administrations are considering appropriate measures on a case by case to protect the services/systems operating through the BS allocation (T-DAB) from PWMS emissions.

It is also possible that some administrations may elect not to deploy L band T-DAB services, leaving this band very suitable for geographic sharing.

5.4 Compatibility between PWMS devices and Broadcasting Satellite service (1479.5-1492 MHz)

At international level, WARC-92 allocated the band 1452-1492 MHz on a **co-primary basis** to the broadcasting-satellite service (sound) and complementary terrestrial audio broadcasting. These allocations form the basis of the deployment of satellite and terrestrial components of S-DAB hybrid systems, whereas the introduction of satellite components of S-DAB systems is limited at global level to the 1467-1492 MHz band, as a result of ITU Resolution 528.

In Europe, the frequency band 1452-1479.5 MHz was used as a basis for the development of a T-DAB plan, whereas the 1479.5-1492 MHz band is harmonised for S-DAB use since October 2003, as a result of the adoption of ECC/DEC/(03)02 [16]. In effect, this CEPT Decision provides scope for a harmonised deployment of satellite and terrestrial components of S-DAB hybrid systems in the upper 12.5 MHz of the 1452-1492 MHz international allocation:

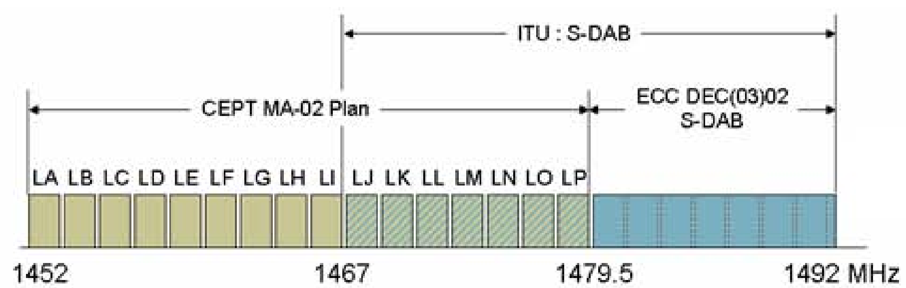


Figure 9: International and European BS and BSS allocations in the frequency band 1452-1492 MHz

In Q4-2006, the ETSI has published a series of documents which establish the “Satellite Digital Radio” (SDR) standard:

- ETSI TR 102 525 (2006-09), technical report on SDR technology [17]
- ETSI TS 102 550 (2006-11), Outer Physical Layer [18]
- ETSI TS 102 551-1 (2006-12), SDR Inner Physical Layer Single Carrier [19]
- ETSI TS 102 551-2 (2006-12), SDR Inner Physical Layer Multiple Carrier [20]

This standard identifies the 1.5 GHz band as the main candidate band for the deployment of SDR-compliant hybrid technologies.

5.4.1 Compatibility analyses

Compatibility studies to be carried out between PWMS systems and S-DAB systems in the 1479.5-1492 MHz band are twofold, and need to address both the satellite and terrestrial components of such S-DAB hybrid systems.

Compatibility of PWMS systems with terrestrial components of S-DAB hybrid systems

Terrestrial components of S-DAB hybrid systems consist in complementary gap-filler networks to be deployed in areas where the satellite reception is subject to line-of-sight blockage – primarily urban areas – where the satellite signal is likely to be blocked by natural obstacles or buildings.

Depending on the size of the complementary terrestrial coverage to be achieved, these local networks may consist of single transmitters or OFDM SFNs. Although the SDR terrestrial component waveform slightly differs from the T-DAB EU-147 OFDM waveform, the design of local S-DAB terrestrial gap-filler networks basically obey to a similar link budget, and it is therefore proposed that results of compatibility studies to be developed between T-DAB and PWMS systems in the 1452-1479.5 MHz band be extended to apply in the 1479.5-1492 MHz to cover the case of compatibility between PMWS systems and S-DAB terrestrial components.

Compatibility of PWMS systems with satellite components of S-DAB hybrid systems

The SDR standard defines various profiles for satellite component carriers. The analyses presented in this document are based on the 1.49 Msps carrier profile (1.71 MHz channel bandwidth).

S-DAB receivers operate on the satellite link with a G/T of -22 dB/K, and a reception antenna of 2 dBi. Because this antenna is designed for mobile reception, no antenna gain discrimination can be factored when addressing interference potentials.

The table below defines the resulting PWMS maximum interference level into a 1.49 Msps S-DAB carrier:

Channel bandwidth	1712	kHz
G/T	-22.0	dB/K
Antenna gain	2.0	dBi
Receiver noise temperature	251	K
Receiver thermal noise level	-142	dBW
Required I/N criterion	-20	dB
$\mathbf{I_{max}}$	-162	dBW

Table 11: PWMS maximum interference level into a 1.71 MHz AB carrier

a) PWMS single carrier compatibility analysis: co-channel case

This section aims at defining the separation distance which would be necessary to ensure the protection of an S-DAB satellite component reception from a co-channel PWMS single carrier emission, according to the maximum interference level defined in Table 1.

Because the S-DAB channel bandwidth (1.712 MHz – 1.49 Msps SDR profile) is larger than that of either PWMS carrier (200 kHz or 600 kHz), this single carrier interference analysis is expected to apply to both types of PWMS carriers.

A low power PWMS interferer is considered (50 mW), and is assumed to be radiated from an in-door location (a wall absorption of 10 dB is considered):

PWMS radiated power (50 mW)	-13	dBW
Wall absorption	-10	dB
Path loss[1] Attenuation	-141	dB
Separation distance	**2.9**	**km**
S-DAB receiver antenna gain	+2	dBi
$\Rightarrow \mathbf{I = I_{max}}$	-162	dBW

Table 12: Required separation distance from an indoor co-channel PWMS interferer (50 mW, 200 kHz or 600 kHz, single carrienterference

b) PWMS single carrier compatibility analysis: adjacent channel case

This section aims at defining the separation distance which would be necessary to ensure the protection of an S-DAB satellite component reception from a PWMS single carrier emission at a given frequency offset. Like in section a) above, indoor low-power PWMS carriers are considered.

The spectrum mask reproduced in figures B.4 (B=600 kHz) of document ETSI TR 102 546 [1] is used for PWMS emissions, which are assumed to interfere into the following equivalent S-DAB receiver filter[2]:

[1] Based on the Extended Hata propagation model implemented in SEAMCAT, in rural environment
[2] Cascading of a SAW filter and a Nyquist filter

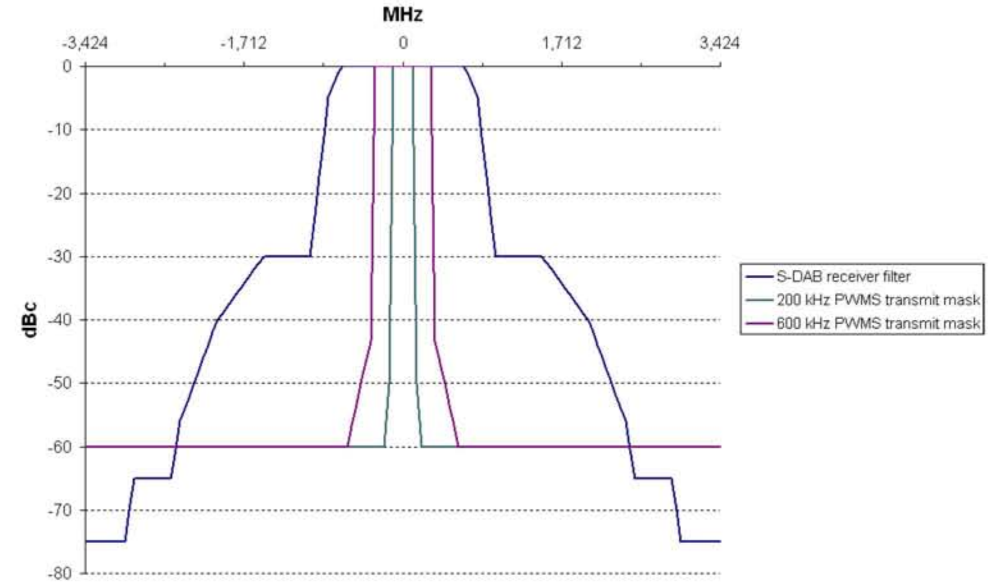


Figure 10: S-DAB and PWMS spectrum masks

These S-DAB and PWMS masks are then correlated to derive the ACI relaxation which can be applied at a given frequency offset:

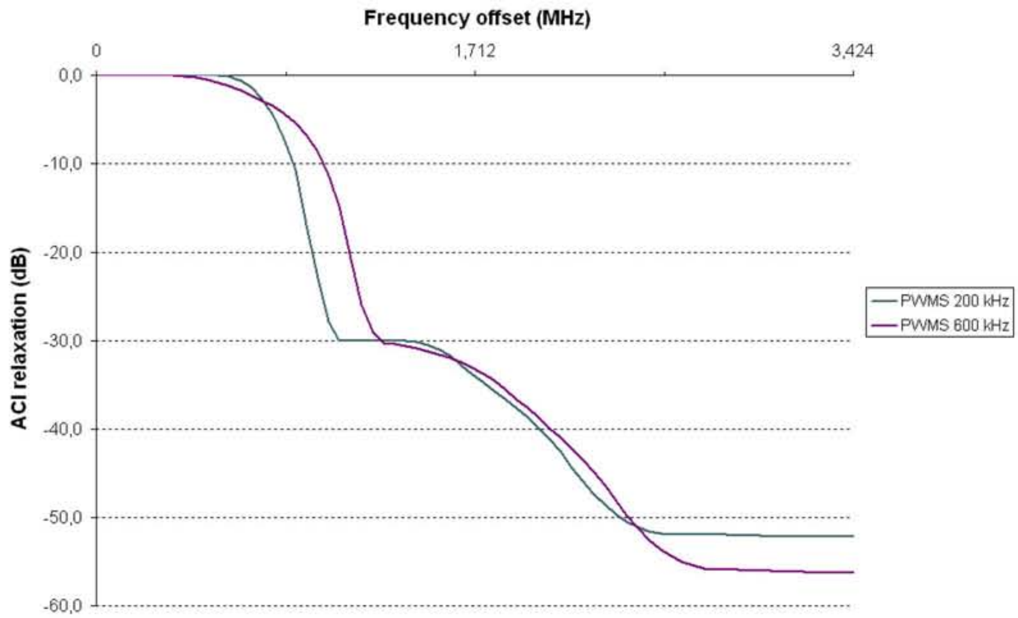


Figure 11*:* ACI relaxation masks

For each value of frequency offset, the corresponding relaxation is applied in order to derive the separation distance[1] which is necessary to ensure the protection of an S-DAB satellite component carrier ($I \leq I_{max}$ as defined in Table 11) from a 50 mW PWMS (indoor) transmission:

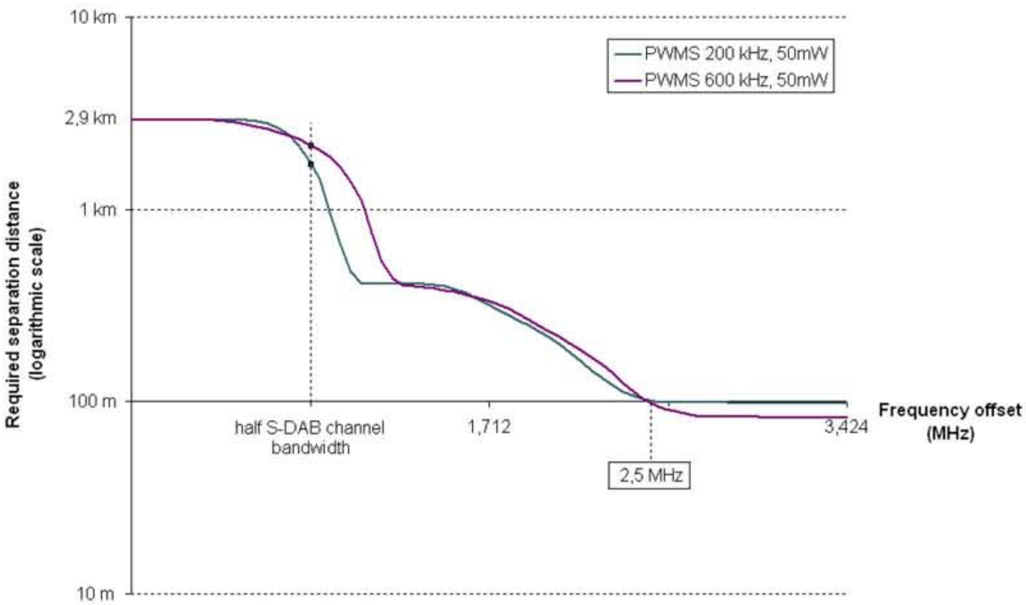


Figure 12: Separation distance required from an indoor adjacent channel PWMS interferer (50 mW, 200 kHz and 600 kHz, single carrier interference) for wall absorption = 10dB

If PMWS are located outdoor (i.e. band below 1479.5 MHz), it will not be possible to reach the 100 m point, therefore a rejection of 70 dB is considered.

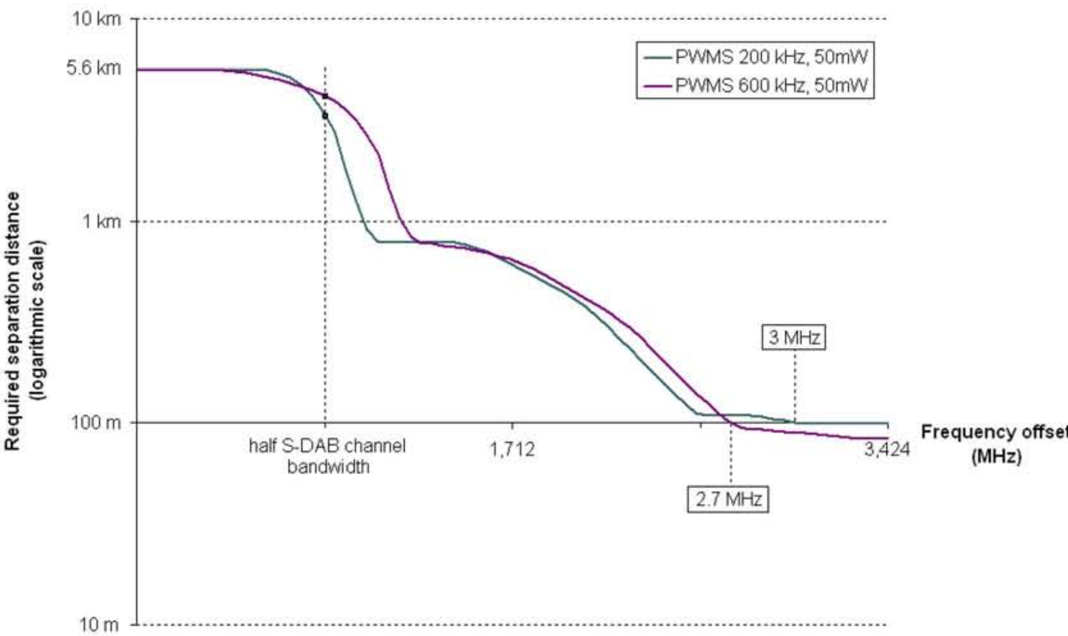


Figure 13: Separation distance required from an outdoor adjacent channel PWMS interferer – 70dB rejection (50 mW, 200 kHz and 600 kHz, single carrier interference)

For 50 mW outdoor emissions of resp. 200 kHz and 600 kHz would require guard bands of 2.0 and 1.5 MHz to ensure compatibility with S-DAB satellite component operating in the 1479.5-1492 MHz band. If the systems are indoor the guard bands would become 1.5 MHz and 1.3 MHz.

The following table provides the results in term of guard band for the indoor / outdoor case.

	outdoor	**Indoor**
200 kHz	2 MHz	1.5 MHz
600 kHz	1.5 MHz	1.3 MHz

Table 13: guard bands indoor / outdoor case

<u>In-band</u>

- <u>compatibility:</u>

  Figure 12 shows that the operation of even low-power indoor PWMS systems is not possible within the 1479.5-1492 MHz allocation, since a minimum between 1.8 km and 2.9 km of separation distance is necessary between a PWMS transmitter and an S-DAB receiver to mitigate the interference potential in all cases of frequency offsets (up to half the S-DAB channel bandwidth).

- <u>Out-of-band compatibility:</u>

For indoor PWMS deployment (above 1492 MHz): According to Figures 12 1.5 MHz guard band is needed with a rejection of 60 dB is needed resulting in a level of 17dB – 60dB = - 43dBm in 600 kHz for the PWMS unwanted emissions falling below 1492 MHz.

For outdoor PWMS deployment (below 1479.5): According to Figures 13, 2 MHz guard band is needed with a rejection of 70 dB is needed resulting in a level of 17dB – 70dB = - 53dBm in 600 kHz for the PWMS unwanted emissions falling above 147 MHz. .

5.4.2 Conclusions

Co-channel interference analyses demonstrate that PWMS systems – even low power (50 mW) and radiating from in-door locations – are not compatible with S-DAB satellite components, and can therefore not operate within the 1479.5-1492 MHz band.

PWMS with 50 mW emissions appear however possible in bands immediately adjacent to the 1479.5-1492 MHz European S-DAB allocation, subject to the accommodation of guard bands of 2 MHz in order to restrict PWMS deployment in frequency bands above 1493.5 MHz and below 1477.5 MHz. The level of unwanted emissions in the S-DAB band should not exceed -58dBm in 600 kHz taking into account the possible aggregated impact of PWMS systems.

5.5 Compatibility between PWMS devices and Aeronautical Telemetry

Deployment limited to some CEPT countries. It is proposed to determine a separation distance to protect the aeronautical systems in the whole band.

Table 14 summarises the technical parameters used in order to assess the impact of PWMS on Aeronautical systems. The simulation results are extracted using the SEAMCAT simulator. It should be noted that the interference scenarios and results of calculations presented below refer to ground stations of aeronautical telemetry systems only (downlink). The interference level in uplink interference scenarios (interference to the aircraft telemetry receiver) is assumed to be higher than in downlink.

	Common Parameters	**Value**	**Description**
Victim Link	Interference Criterion (I/N) [dB]	-3.0	
	Frequency Constant [MHz]	1494	
	Reception bandwidth [kHz]	1000	
	Noise Floor Constant [dBm]	-112.0	
	Antenna Heigth [m]	50	
	Antenna Gain [dBi]	41.2	
	Antenna pattern	ITU R M.1459	See Figure 13
	Azimuth [deg]	0 to 360	Uniform Distribution
	Elevation [deg]	3 to 80	Uniform Distribution
Interference Link	Frequency Constant [MHz]	1494	
	Power Supplied Constant [dBm]	14.86	
	Reference Bandwidth [kHz]	200	
	Antenna Height [m]	1.5 to 6.0	Discrete Uniform Distribution (step of 0.5 m)
	Antenna pattern	Omni-directional	
	Peak Gain [dBi]	2.14	
	Azimuth [deg]	0 to 360	Uniform Distribution
	Interference Path Correlation	Closest Interferer	The interference value is calculated from where the interferer is closest to the protection distance
	Protection distance [km]	2-36	
	Path azimuth [deg]	0 to 360	Uniform Polar Angle distribution
	Propagation Model	Extended Hata	General Environment: rural, suburban Local Environment Victim: outdoor Local Environment Interferer: outdoor

Table 14: Common technical parameters for the simulations

The figure below provides the assumed antenna pattern for aeronautical system.

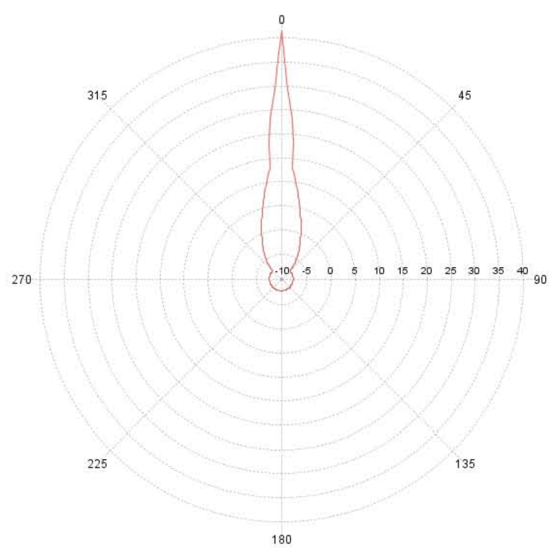


Figure 14: Antenna Pattern given by the ITU R M.1459 [21]

Local Environment Interferer	Wall Attenuation [dB]	Required separation distance, km (with ≈1% probability of interference)		
		Rural	Suburban	Urban
Outdoor	0	36	12.5	5.5

Table 15: Results of simulations

5.6 Discussion for the band 1452-1492 MHz

PWMS was found not compatible with **BSS** in the frequency range 1479.5 to 1492 MHz. In addition, a guard band of 2 MHz should be considered at the edges of the band 1479.5 – 1492 MHz in order to protect BSS systems. This implies that there should not be deployment of PWMS in the frequency range 1477.5 to 1494 MHz. In addition, unwanted emission level of -58dBm in 600 kHz in the BSS band should be met within any 600 kHz in the BSS band 1479.5 to 1492 MHz.

For **T-DAB**, no general guidance is provided since the situations are going to differ from administration to administration.

Aeronautical Telemetry systems:

Based on the results obtained with SEAMCAT simulations it can be concluded that in rural and suburban areas the compatibility of PWMS systems with aeronautical telemetry systems may be achieved with restriction of separation distances between PWMS transmitter and Aeronautical Telemetry receiver:

- 36 km in rural and 12.5 km in suburban area for outdo or PWMS systems;
- In urban area compatibility of PWMS systems with aeronaut ystem sisetry systems is achieved.

Since the exact frequencies used by Aeronautical systems are not known, these separation distances will have to applicable over the whole frequency range used by aeronautical systems (i.e. 1429-1492 MHz for the PWMS outdoor case).

Fixed and Mobile

A separation distance of 15 km is necessary for the co-channel case to protect the frequencies received by FS station. theThe unwanted emissions of PWMS operating in the band 1452 – 1477.5 MHz at the frequency received by FS stations in the frequency range 1452-1492 MHz should meet:

- A rejection of 65dB, corresponding to a level of: 17-65dB=-48dBm in 200 kHz

The limits given in section 4.4 are also applicable.

These conclusions are valid for both analogue and digital cases and for outdoor deployment.

6 COMPATIBILITY STUDIES IN THE BAND 1492-1518 MHZ

6.1 Compatibility between PWMS and Fixed Service

In this band the Fixed Service has a Primary Status therefore the value of the I/N will be -20dB. It is proposed to limit the use of PWMS to indoor usage, therefore a 10dB attenuation will have to be considered. Considering the difference of I/N (-20dB instead of -10dB) and the difference of PWMS usage (indoor instead of outdoor), it can be conclude that the conclusions given in section 5.1 are applicable.

6.2 Compatibility between PWMS and Mobile Service

According to EU15A, the use of the bands considered in this report by the Mobile Service is limited to tactical radio relay applications. Therefore, the considerations given in section 6.1 with regard to the Fixed Service are applicable.

6.3 Compatibility between PWMS and Aeronautical

The same approach as in section 5.5 is considered, taking into account the fact that the usage of PWMS will be limited to indoor usage. The following table provides the corresponding separation distances calculated using SEAMCAT.

Local Environment Interferer	Wall Attenuation [dB]	Required separation distance, km (with ≈1% probability of interference)		
		Rural	Suburban	Urban
Indoor	6	28	8	3.5
Indoor	30	6	1.5	0.7

Table 16: Results of simulations – indoor case

Therefore, based on the results obtained with SEAMCAT simulations it can be concluded that in rural and suburban areas the compatibility of PWMS systems with aeronautical telemetry systems may be achieved with restriction of separation distances between PWMS transmitter and Aeronautical Telemetry receiver:

- 28 km in rural and 8 km in suburban area for indoor (Thermoplane shielding) PWMS systems;
- 6 km in rural and 1.5 km in suburban area for indoor (Lime sandstone shielding) PWMS systems;

In urban area compatibility of PWMS systems with aeronautical telemetry systems is achieved.

6.4 Conclusions

Aeronautical Telemetry systems:

Based on the results obtained with SEAMCAT simulations, it can be concluded that in rural and suburban areas the compatibility of indoor PWMS systems with aeronautical telemetry systems may be achieved with restriction of separation distances between PWMS transmitter and Aeronautical Telemetry receiver:

- 28 km in rural and 8 km in suburban area for indoor (Thermoplane shielding) PWMS systems;
- 6 km in rural and 1.5 km in suburban area for indoor (Lime sandstone shielding) PWMS systems;

In urban area compatibility of PWMS systems with aeronautical telemetry systems is achieved.

Since the exact frequencies used by Aeronautical systems are not known, these separation distances will have to applicable over the whole frequency range used by aeronautical systems (i.e. 1492-1518 MHz for the PWMS indoor case).

Fixed and Mobile

A separation distance of 15 km is necessary for the co-channel case to protect the frequencies received by FS station.

The following level should be met by the PWMS operating in the band 1492-1518 MHz at the frequency received by FS stations at a receiving station:

- A rejection of 65dB is needed, corresponding to a level of: 17-65dB=-48dBm in 200 kHz

See also section 5.6 for the protection of BSS operating below 1518 MHz and section 7.5 for the protection of MSS operating above 1518 MHz.

7 COMPATIBILITY STUDIES IN THE BAND 1518-1530 MHz

7.1 Compatibility between PWMS and Fixed Service or Mobile Service

See section 6.1 and 6.2.

7.2 Compatibility between PWMS devices and Mobile Satellite service

7.2.1 MSS characteristics

For the compatibility studies it is appropriate to consider the following three types of representative GSO MES terminals:

- GAN
- BGAN
- Handheld

The parameters for MSS systems are given in Table 17 below.

	GAN	BGAN	Hand-held
Channel Rate (kbps)	65.2	732	28.8
Symbol Rate (ksps)	33.6	183	33.85
Bandwidth (kHz)	60	200	50
G/T of the terminal (dB/ºK)	-7	-9	-23
Antenna Peak Gain (dBi)	18	17	2
Antenna Radiation Pattern	G= 18 dBi for 0º ≤ø < 30º G=41-25 log(ø) dBi for 30º ≤ ø < 63º G= -4 dBi for ø ≥ 63º	G= 17 dBi for ø < 7º G= 0.0026 $ø^2$-0.5029ø+20.27914 dBi for 7º ≤ ø < 76º G= -3 dBi for ø ≥ 76º	G= 2 dBi for ø < 45º G= 0 dBi for ≤ ø ≥ 45º
Required I/N criterion (dB)	-20	-20	-20

Table 17: Typical MSS power flux densities

Inmarsat Carrier Parameters			
Carrier Type		**Max EIRP***	**BW**
		dBW	**kHz**
GAN	Inmarsat-3	31.3	60
BGAN	Inmarsat-4	44.8	200
Hand-held	Inmarsat-4	43	50
*** Typical operational beam peak levels**			
PFD Calculations			
	Range	40000	Km
	Spreading loss	163.0	dBm2
GAN	Inmarsat-3	-119.5	dB(W/m2/MHz)
BGAN	Inmarsat-4	-111.2	dB(W/m2/MHz)
Hand-held	Inmarsat-4	-107.0	dB(W/m2/MHz)
Other satellite networks			
Thuraya (Source: EMARSAT-1F Filing)			
200KG7W	Max e.i.r.p	63	dBW
	Range	39500	Km
	Spreading loss	162.9	dBm2
	BW	200	kHz

	PFD	**-92.9**	dB(W/m2/MHz)
Aces (Source: Garuda-2 Filing)			
50K0G7W	Max e.i.r.p	59.8	dBW
	Range	39500	Km
	Spreading loss	162.9	dBm2
	BW	50	kHz
	PFD	**-90.1**	dB(W/m2/MHz)

Table 18: Typical MSS power flux densities

7.2.2 Impact of PWMS on MSS

Co-channel interference analysis

In this section, interference analysis is presented taking into account the following propagation models:

- Free space attenuation
- Free space attenuation up to 5 km and 40 log d attenuation beyond 5 km
- Hata propagation model in urban, sub-urban, rural/flat environments

A building attenuation value of 10 dB is assumed. In addition, for the interfering PWMS system two values of bandwidth have been considered in the analysis: 200 kHz and 600 kHz.

The summary of the analysis is given below.

	Co-channel Scenario			
	GAN	BGAN	Hand held	
Propagation model		Free space		
Case-1				
Interferer BW	200	200	200	kHz
Building attenuation	10	10	10	dB
Distance	0.1	0.1	0.1	km
Int Margin	-67.42	-67.42	-71.42	dB
Req distance to achieve zero margin	234.90	234.90	372.29	km
Case-2				
Interferer BW	600	600	600	kHz
Building attenuation	10	10	10	dB
Distance	0.1	0.1	0.1	km
Int Margin	-62.65	-62.65	-66.65	dB
Req distance to achieve zero margin	136	136	215	km

Propagation model		Free space up to 5 km and 40 log d beyond 5 km		
Case-1				
Interferer BW	200	200	200	kHz
Building attenuation	10	10	10	dB
Distance	6	6	6	km
Int Margin	-30.27	-30.27	-34.27	dB
Req distance to achieve zero margin	34.27	34.27	43.14	km
Case-2				
Interferer BW	600	600	600	kHz
Building attenuation	10	10	10	dB
Distance	6	6	6	km
Int Margin	-25.50	-25.50	-29.50	dB
Req distance to achieve zero margin	26	26	33	km

Table 19: Summary of the results

Interference analysis for free space attenuation propagation model is presented in Table 19 and for a combination of free space attenuation and 40 log d attenuation is Table 20. Interference analyses for Hata propagation model are presented in Tables 21 and 22 for interfering PWMS systems bandwidth of 200 kHz and 600 kHz respectively.

	GAN	BGAN	Hand held	Units
Bandwidth	60	200	50	kHz
G/T	-7	-9	-23	dB/K
Antenna Peak Gain	18	17	2	dBi
Receiver Noise Temp	316	398	316	K
Receiver thermal Noise Level	-155.82	-149.59	-156.61	dBW
Required I/N Crietrion	-20	-20	-20	dB
I max	**-175.82**	**-169.59**	**-176.61**	dBW
Antenna Backlobe gain	-4	-3	0	dBi

Propagation Model	**Free Space Propagation**			
	Co-channel scenario			
Case-1	**PWMS BW: 200 kHz**			
Building Attenuation Loss	10	10	10	dB
Maximum Radiated Power	50	50	50	mW
Maximum Radiated Power	-13.0	-13.0	-13.0	dBW
Bandwidth	200	200	200	kHz
Frequency	1542	1542	1542	MHz
Distance	**0.1**	**0.1**	**0.1**	**km**
Free space loss	76.16	76.16	76.16	dB
Receive Antenna Gain	-4.00	-3.00	0.00	dBi
Bandwidth Correction Factor	-5.23	0.00	-6.02	dB
Received interference level	**-108.40**	**-102.17**	**-105.19**	dBW
Interference Margin	**-67.42**	**-67.42**	**-71.42**	dB

Case-2	**PWMS BW: 600 kHz**			
Building Attenuation Loss	10	10	10	dBi
Maximum Radiated Power	50	50	50	mW
Maximum Radiated Power	-13.0	-13.0	-13.0	dBW
Bandwidth	600	600	600	kHz
Frequency	1542	1542	1542	MHz
Distance	**0.1**	**0.1**	**0.1**	**km**
Free space loss	76.16	76.16	76.16	dB
Receive Antenna Gain	-4.00	-3.00	0.00	dBi
Bandwidth Correction Factor	-10.00	-4.77	-10.79	dB
Received interference level	**-113.17**	**-106.94**	**-109.96**	dBW
Interference Margin	**-62.65**	**-62.65**	**-66.65**	dB

Table 20: Interference analysis for free space attenuation propagation model

	GAN	BGAN	Hand held	Units
Bandwidth	60	200	50	kHz
G/T	-7	-9	-23	dB/K
Antenna Peak Gain	18	17	2	dBi
Receiver Noise Temp	316	398	316	K
Receiver thermal Noise Level	-155.82	-149.59	-156.61	dBW
Required I/N Crietrion	-20	-20	-20	dB
I max	**-175.82**	**-169.59**	**-176.61**	dBW
Antenna Backlobe gain	-4	-3	0	dBi

Propagation Model	**Free Space Propagation upto 5 km**			
Co channel Scenario	**& 40 log d beyond 5 km**			
Case-1	**PWMS BW: 200 kHz**			
Building Attenuation Loss	10	10	10	dB
Maximum Radiated Power	50	50	50	mW
Maximum Radiated Power	-13.0	-13.0	-13.0	dBW
Bandwidth	200	200	200	kHz
Frequency	1542	1542	1542	MHz
Distance	**6**	**6**	**6**	**km**
Free space loss	113.31	113.31	113.31	dB
Receive Antenna Gain	-4.00	-3.00	0.00	dBi
Bandwidth Correction Factor	-5.23	0.00	-6.02	dB
Received interference level	**-145.55**	**-139.32**	**-142.34**	dBW
Interference Margin	**-30.27**	**-30.27**	**-34.27**	dB

Case-2	**PWMS BW: 600 kHz**			
Building Attenuation Loss	10	10	10	dBi
Maximum Radiated Power	50	50	50	mW
Maximum Radiated Power	-13.0	-13.0	-13.0	dBW
Bandwidth	600	600	600	kHz
Frequency	1542	1542	1542	MHz
Distance	**6**	**6**	**6**	**km**
Free space loss	113.31	113.31	113.31	dB
Receive Antenna Gain	-4.00	-3.00	0.00	dBi
Bandwidth Correction Factor	-10.00	-4.77	-10.79	dB
Received interference level	**-150.32**	**-144.09**	**-147.11**	dBW
Interference Margin	**-25.50**	**-25.50**	**-29.50**	dB

Table 21: Interference analysis for "free space attenuation (up to 5 km) and 40 log d attenuation (beyond 5km)" propagation model

	GAN	BGAN	Hand held	Units
Bandwidth	60	200	50	kHz
G/T	-7	-9	-23	dB/K
Antenna Peak Gain	18	17	2	dBi
Receiver Noise Temp	316	398	316	K
Receiver thermal Noise Level	-155.82	-149.59	-156.61	dBW
Required I/N Crietrion	-20	-20	-20	dB
I max	**-175.82**	**-169.59**	**-176.61**	dBW
Antenna Backlobe gain	-4	-3	0	dBi

Propagation Model	**COST-231 Hata Model**			
Case-1	**PWMS BW: 200 kHz**			
Building Attenuation Loss	10	10	10	dB
Maximum Radiated Power	50	50	50	mW
Maximum Radiated Power	-13.0	-13.0	-13.0	dBW
Bandwidth	200	200	200	kHz
Frequency	1542	1542	1542	MHz
Distance (urban environment)	**0.1**	**0.1**	**0.1**	**km**
Distance (sub-urban and rural open environment	**0.1**	**0.1**	**0.1**	**km**
Parameter (ahm)				
hr (victim receiver antenna height)	2	2	2	meters
height of the base station hb	8	8	8	meters
ahm (urban environment)	1.05	1.05	1.05	dB
ahm(suburban and rural(flat) environments)	1.44	1.44	1.44	dB
Parameter Cm				
for urban area	3	3	3	dB
for suburban or open environments	0	0	0	dB
Path loss (uran environment)	104.87	104.87	104.87	dB
Path loss (suburban and open environment)	101.47	101.47	101.47	dB
Receive Antenna Gain	-4.00	-3.00	0.00	dBi
Bandwidth Correction Factor	-5.23	0.00	-6.02	dB
Received interference level in urban environment	**-137.10**	**-130.88**	**-133.90**	dBW
Interference Margin in urban environment	**-38.71**	**-38.71**	**-42.71**	dB
Received interference level in suburban environment	**-133.71**	**-127.48**	**-130.50**	dB
Interference Margin in suburban environment	**-42.11**	**-42.11**	**-46.11**	dB

Table 22: Interference analysis for Hata Propagation model (PWMS bandwidth of 200 kHz)

	GAN	BGAN	Hand held	Units
Bandwidth	60	200	50	kHz
G/T	-7	-9	-23	dB/K
Antenna Peak Gain	18	17	2	dBi
Receiver Noise Temp	316	398	316	K
Receiver thermal Noise Level	-155.82	-149.59	-156.61	dBW
Required I/N Crietrion	-20	-20	-20	dB
I max	**-175.82**	**-169.59**	**-176.61**	dBW
Antenna Backlobe gain	-4	-3	0	dBi

Propagation Model	**COST-231 Hata Model**

Case-2	**PWMS BW: 600 kHz**			
Building Attenuation Loss	10	10	10	dB
Maximum Radiated Power	50	50	50	mW
Maximum Radiated Power	-13.0	-13.0	-13.0	dBW
Bandwidth	600	600	600	kHz
Frequency	1542	1542	1542	MHz
Distance (urban environment)	**0.1**	**0.1**	**0.1**	**km**
Distance (sub-urban and rural open environment	**0.1**	**0.1**	**0.1**	**km**
Parameter (ahm)				
hr (victim receiver antenna height)	2	2	2	meters
height of the base station hb	8	8	8	meters
ahm (urban environment)	1.05	1.05	1.05	dB
ahm(suburban and rural(flat) environments)	1.44	1.44	1.44	dB
Parameter Cm				
for urban area	3	3	3	dB
for suburban or open environments	0	0	0	dB
Path loss (uran environment)	104.87	104.87	104.87	dB
Path loss (suburban and open environment)	101.47	101.47	101.47	dB
Receive Antenna Gain	-4.00	-3.00	0.00	dBi
Bandwidth Correction Factor	-10.00	-4.77	-10.79	dB
Received interference level in urban environment	**-141.88**	**-135.65**	**-138.67**	dBW
Interference Margin in urban environment	**-33.94**	**-33.94**	**-37.94**	dB
Received interference level in suburban environment	**-138.48**	**-132.25**	**-135.27**	dBW
Interference Margin in suburban environment	**-37.34**	**-37.34**	**-41.34**	dB

Table 23: Interference analysis for Hata Propagation model (PWMS bandwidth of 600 kHz)

Interference analysis with PWMS Transmitter emission mask

In this section an analysis is performed to estimate the frequency offset required between the victim MSS MES terminals and the interfering PWMS system with 600 kHz bandwidth.

The PWMS transmitter emission mask used in the analysis is given in Figure 2.

The required separation distances in km as a function of frequency offset between the interfering transmitter and victim MES terminal receiver for free space propagation model and “free space attenuation up to 5 km and 40 log d attenuation beyond 5km” propagation model are given in Figures 23 and 24 respectively.

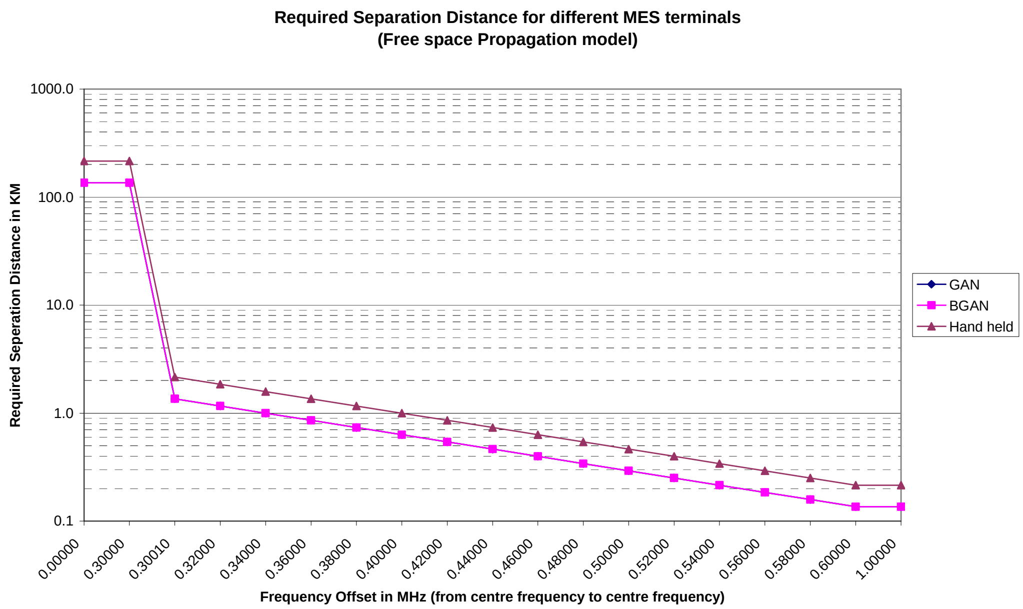


Figure 15: Required separation distance from PWMS interferer (50 mW and 600 kHz; building attenuation = 10 dB) under free space propagation model

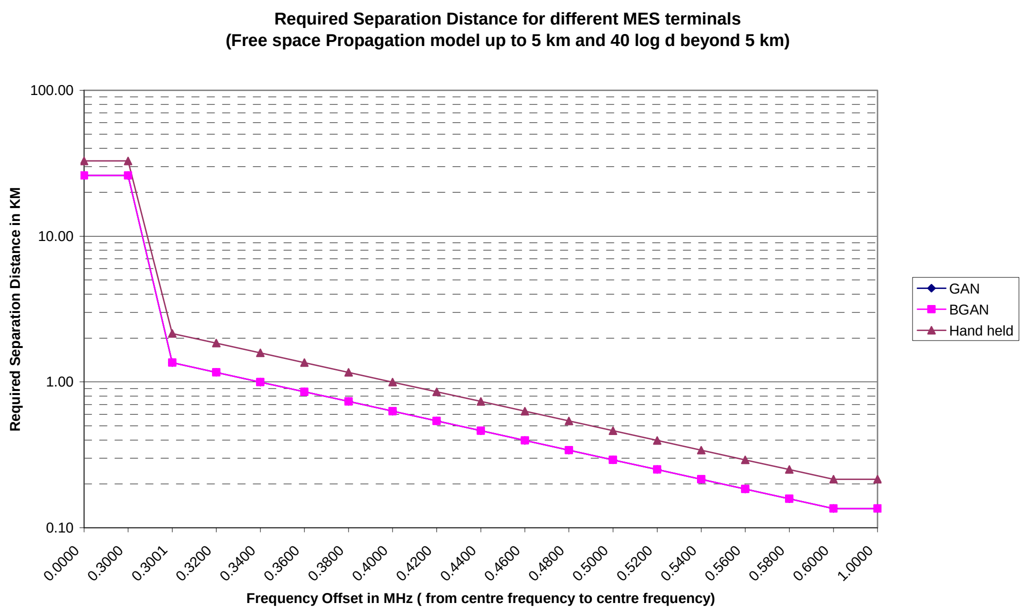


Figure 16: Required separation distance from PWMS interferer (50 mW and 600 kHz; building attenuation = 10 dB) under “free space attenuation up to 5 km and 40 log d attenuation beyond 5 km” propagation model

Conclusion

From the analysis the following conclusions can be drawn.

Free space propagation model

- At a separation distance of 100 m the interference deficits vary from 67.42 dB to 71.42 dB for an interfering system bandwidth of 200 kHz and from 62.65 dB to 66.65 dB for an interfering system bandwidth of 600 kHz.

- Separation distances ranging from 235 km to 372 km for an interfering system bandwidth of 200 kHz and from 136 km to 215 km for an interfering system bandwidth of 600 kHz are required to protect mobile earth stations.
- At a frequency offset of 600 kHz to 1 MHz (between the centre frequencies of victim MES receiver and interfering PWMS transmitter of 600 kHz bandwidth), separation distances ranging from 140 meters to 220 meters are required to protect mobile earth stations

“Free space attenuation up to 5m and 40 log d attenuation beyond 5 km” propagation model

- At a separation distance of 6 km the interference deficits vary from 30.27 dB to 34.27 dB for an interfering system bandwidth of 200 kHz and from 25.5 dB to 29.5 dB for an interfering system bandwidth of 600 kHz.
- Separation distances ranging from 34 km to 43 km for an interfering system bandwidth of 200 kHz and from 26 km to 33 km for an interfering system bandwidth of 600 kHz are required to protect mobile earth stations.
- At a frequency offset of 600 kHz to 1 MHz (between the centre frequencies of victim MES receiver and interfering PWMS transmitter of 600 kHz bandwidth), separation distances ranging from 140 meters to 220 meters are required to protect mobile earth stations

Hata propagation model

- At a separation distance of 0.1 km the interference deficits vary from 38.71 dB to 42.71 dB in urban environment and from 42.11 dB to 46.11 dB in sub-urban and rural environments for an interfering system bandwidth of 200 kHz.
- At a separation distance of 0.1 km the interference deficits vary from 33.94 dB to 37.94 dB in urban environment and from 37.34 dB to 41.34dB in sub-urban and rural environments for an interfering system bandwidth of 600 kHz.
- Separation distances ranging from 0.98 km to 1.25 km in urban environment and from 1.2 km to 1.52 km in sub-urban and rural environments for an interfering system bandwidth of 200 kHz are required to protect mobile earth stations.
- Separation distances ranging from 0.74 km to 0.94 km in urban environment and from 0.91 km to 1.15 km in sub-urban and rural environments for an interfering system bandwidth of 600 kHz are required to protect mobile earth stations.

It is concluded that sharing between MSS systems and PWMS systems is not feasible. Possible mitigation techniques, such as Detect and Avoid, etc., have not yet been studied and should be further investigated.

7.3 Compatibility between PWMS devices and Space Operation

This band is not listed in ITU-R Rec. RS.1166-3 [22] which provides the bands for Space Operation and there was no support to consider this case, therefore, this case is not covered.

7.4 Compatibility between PWMS devices and Aeronautical Telemetry

See 6.3.

7.5 Discussion for the band 1518-1530 MHz

Since PWMS are not compatible with **MSS** this band should not be made available for PWMS. In addition a guard band of 600 kHz should be implemented at the edge of the frequency range 1517 to 1518 MHz in order to protect the operation of MSS systems. The unwanted emission from PWMS should not exceed 17dBm-70=-53dBm in 600 kHz in the band 1518-1530 MHz.

The conclusions given in section 6.5 for **Fixed / Mobile** are applicable.

Based on the results obtained with SEAMCAT simulations it can be concluded that in rural and suburban areas the compatibility of PWMS systems with aeronautical telemetry systems may be achieved with restriction of separation distances between PWMS transmitter and **Aeronautical Telemetry** receiver:

- 28 km in rural and 8 km in suburban area for indoor (Thermoplane shielding) PWMS systems;
- 6 km in rural and 1.5 km in suburban area for indoor (Lime sandstone shielding) PWMS systems;

In urban area compatibility of PWMS systems with aeronautical telemetry systems is achieved.

Since the exact frequencies used by Aeronautical systems are not known, these separation distances will have to applicable over the whole frequency range used by aeronautical systems (i.e. 1492-1535 MHz for the PWMS indoor case).

8 COMPATIBILITY STUDIES IN THE BAND 1533-1559 MHz

8.1 Compatibility between PWMS and Mobile Service

The Mobile Service allocation is limited to 1533-1535 MHz and in this frequency range the status is secondary.

Since no information on the characteristics of mobile systems was available, the characteristics provided in Rec. ITU-R M.1388 [23] are considered (see also table 5).

Thermal noise (kTBF) (noise factor of 5dB)	dB (W/4 kHz)	–162.8		
Antenna gain	dBi	0		
Antenna height	M	1.5		
I/N	dB	-10		
Bandwidth	**kHz**	**12.5**	**25**	**64**
Max allowable interfering power at receiver antenna input	dBm	-138	-135	-131
Max allowable interfering power at receiver antenna input	dBm in 1 KHz	-149	-149	-149

Table 24: Characteristics for Mobile systems

The e.i.r.p. from PWMS being 17dBm, or -6 dBm per kHz. The attenuation to reach the maximum allowable power at the receiver antenna input will be:

-6 dBm per kHz –149 dBm per kHz -10 dB (wall loss attenuation) = 133 dB

Assuming that the mobile deployment is in Urban area, the Urban Extended Hata model could be used. The attenuation of 143 dB will be achieved for a distance of the order of 400 m for the co-channel case.

For the adjacent case, the rejection at the edge of the PWMS bandwidth will be 40dB, which implies that the requested attenuation will be: 133-40dB = 93dB. This distance will be achieved at a distance of about 30 m.

8.2 Compatibility between PWMS devices and Mobile Satellite Service

8.2.1 Impact of PWMS with MSS in the band 1533-1559 MHz excluding the band 1544 – 1545 MHz

See section 7.2.

8.2.2 Impact of PWMS on Cospas-Sarsat MSS in the band 1544 – 1545 MHz

Description of the COSPAS-SARSAT downlink 1544-1545 MHz

Recommendation ITU-R M.1731 [24] « Protection criteria for Cospas-Sarsat local user terminals in the band 1 544-1 545 MHz » provides protection criteria for Cospas-Sarsat local user terminals that receive 1 544-1 545 MHz downlinks from satellites in geostationary and low-Earth orbits. The Cospas-Sarsat system receives and processes signals from emergency position indicating radio beacons (EPIRBs) and other distress beacons operating on 406 MHz. In some cases the signals are delivered to ground stations via a downlink operating in the 1 544-1 545 MHz band. The Cospas-Sarsat global search and rescue satellite-aided system operates within the band 1 544-1 545 MHz which is limited by No. 5.356 of the Radio Regulations (RR) to distress and safety, space-to-Earth communications.

The following table shows the various configurations and corresponding characteristics and interference criteria that can be found in the above recommendation. The maximum interference power spectral-density in dBm/MHz is expressed at the low noise amplifier of the ground station, i.e. at the output of the antenna.

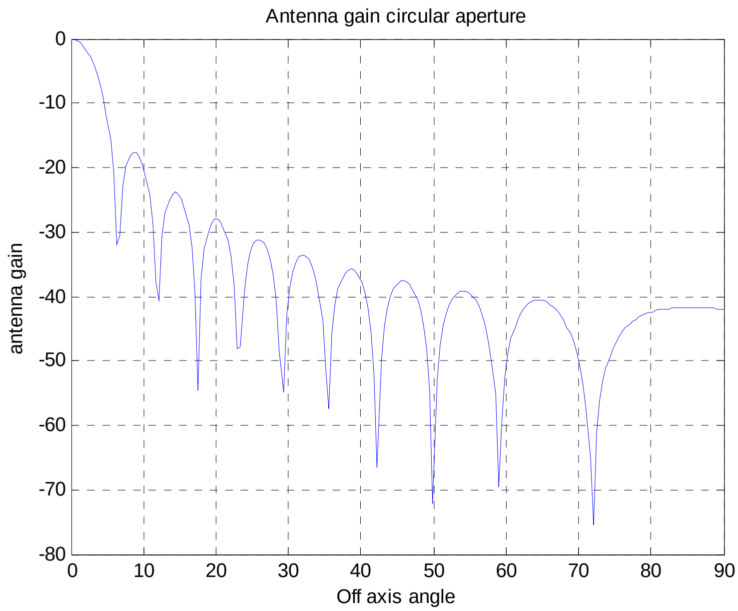


Figure 17: Typical Cospas-Sarsat antenna pattern at 1.5 GHz (ground station)

Type of system	Maximum level of broadband noise-like interference in dB(W/(m^2 · Hz))	Maximum interference power spectral-density in dBm/MHz	Corresponding antenna on-axis gain in dBi
Cospas-Sarsat SAR onboard GOES	−206.4	-108.3	33.3 (first side lobe at 16 dBi)
The Cospas and Sarsat SARP on board low earth orbit satellites	–209.0	-117.5	26.7 (first side lobe at 10 dBi)
The Cospas and Sarsat SARR on board low earth orbit satellites	–206.2	-114.7	26.7 (first side lobe at 10 dBi)
Cospas-Sarsat SARR onboard MSG	–220.5	-119.7	35.7 (first side lobe at 18 dBi)

Table 25: Characteristics and interference criteria in the band 1 544-1 545 MHz for various categories of satellites

Description of the PWMS devices

The PWMS systems to be considered are IEM with the characteristics given in section 4.1.2.

Compatibility analysis with the integral method

The following compatibility analysis makes usage concerning the aggregate case of the integral method. This method is detailed in ECC Report 64 and in the ITU-R TG1/8 Report on UWB. This method computes for a minimum and maximum radius R0 and R1 and for various average densities per km^2, the average aggregate interference power density I in Watts per reference bandwidth written as:

$$I = 2\pi.\alpha\eta\rho \; ln(R_o/R_I)$$

where:

$\alpha = (e.i.r.p.).G_R.(\lambda/4\pi)^2$	:	constant term valid in the case of omnidirectional emissions and free-space propagation;
e.i.r.p	:	average e.i.r.p. of the UWB transmitting device in Watts per reference bandwidth;
λ	:	wavelength in metres;
ρ	:	average density of emitters (emitters per m^2);
η	:	activity factor of emitters;
R_o	:	outer radius of the observed zone;
R_I	:	inner radius of the observed zone.

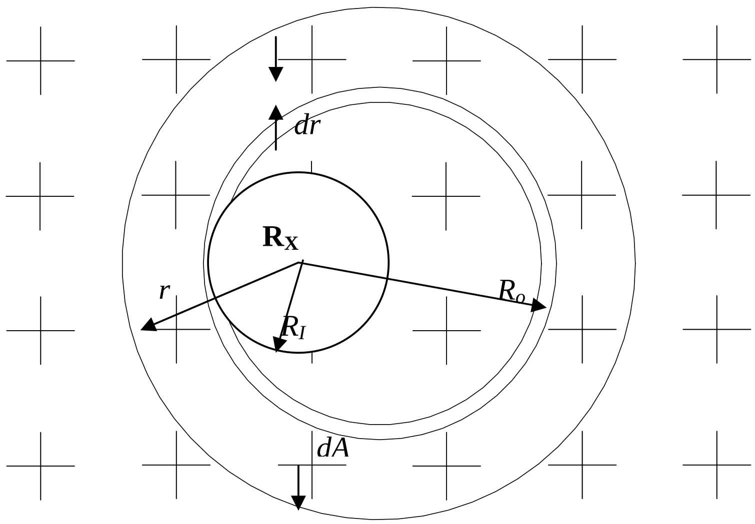


Figure 18: The integral methodology

This compatibility analysis is based on the following assumptions:

- I/N = -6 dB,
- for LEO and GSO satellites, the first side lobe of the antenna is taken into account.

A 100% duty cycle (100 % activity factor) is envisaged by local operators. Therefore, as frequency sharing is impossible, up to 5 microphones (indoor or outdoor) can be in operation within the 1544-1545 MHz band at the same time. The average density of emitters per km2 is therefore 5/(pi*($\boldsymbol{R_o}^2$- $\boldsymbol{R_I}^2$)). Depending on the type of event, wo kinds of operation are planned: outdoor and indoor. For indoor events, an attenuation of 13 dB is used, which corresponds to a Reinforced concrete of 16cm.

Hypothesis for compatibility analysis	Margin for GSO GOES	Margin for LEO SARR	Margin for LEO SARP	Margin for GSO MSG
R_o: 2.7 km **R_I : 2 km** **average density of emitters: 0.5 emitters per km^2**	Indoor case: -44 Outdoor case: -57 Mixed indoor(50%)-outdoor(50%): -55	Indoor case: -45 Outdoor case: -58 Mixed indoor(50%)-outdoor(50%): -55	Indoor case: -48 Outdoor case: -61 Mixed indoor(50%)-outdoor(50%): -58	Indoor case: -71 Outdoor case: -58 Mixed indoor(50%)-outdoor(50%): -68
R_o: 21 km **R_I : 20 km** **average density of emitters: 0.04 emitters per km^2**	Indoor case: -26 Outdoor case: -39 Mixed indoor(50%)-outdoor(50%): -36	Indoor case: -26 Outdoor case: -39 Mixed indoor(50%)-outdoor(50%): -36	Indoor case: -29 Outdoor case: -42 Mixed indoor(50%)-outdoor(50%): -39	Indoor case: -39 Outdoor case: -52 Mixed indoor(50%)-outdoor(50%): -49

Table 26: Compatibility analysis between PWMS devices (except audio) and a Cospas/Sarsat ground station in the band 1 544-1 545 MHz for GSO and LEO satellites

For PWMS audio devices, the above margins are to be decreased by about 10 dB according to the characteristics of the devices as shown in table 2 (spectral density about 10 dB higher for audio).

The table above shows the results for various sets of hypothesis. In all cases, it shows severe cases of interference: in the most favorable case, the margin is -26 dB (indoor case, 20-21 km, LEO SARR, non audio device) and for the worst case, the margin is -71 dB (outdoor case, 2-2.7 km, LEO SARP, audio device). Therefore, it is obvious that PWMS devices are not compatible with MSS within the band 1544-1545 MHz.

Compatibility analysis with SEAMCAT

Victim: Cospas Sarsat for MSG

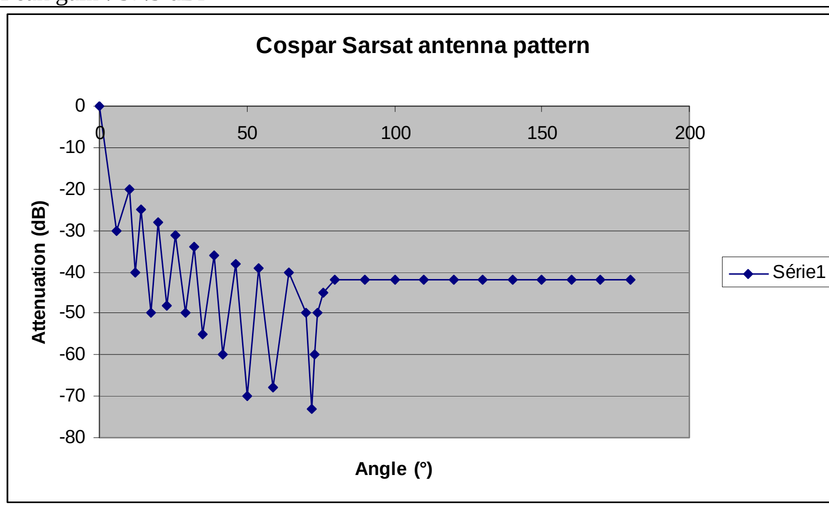
Frequency	1544MHz
Reception bandwidth	80 kHz
Max interference level	-131 dBm for BW=80kHz
Protection criterion	I/N=-20 dB
Noise	-111 dBm
Antenna gain	Azimuth : 0°, Elevation : 0°, Height : 5m Peak gain : 37.5 dBi
Horizontal antenna pattern	

Table 27: Characteristics of Cospas Sarsat for MSG

Interferer: PWMS (Indoor IEM with 10 dB wall attenuation)

Frequency	1544MHz for co-channel, variable for adjacent case
Emission power	9 dBm (EIRP- peak gain)
Bandwidth	200 kHz
Antenna	Peak gain : 8 dBi Azimuth : 0°, Elevation : -45°, Height : 6m
Antenna patterns	See figure 5 for horizontal and vertical pattern
Unwanted emission mask	Digital (see figure 2)
It → Victim location	N=10 PWMS limited in 0-90° sector relative to the victim Density : 0.1 Tx/km2 Probability of transmission : 1, Activity time : 1 Protection distance : variable for co-channel, 100m for adjacent case
It → Victim propagation model	Extended rural Hata Indoor-outdoor with 10 dB indoor-outdoor attenuation

Table 28: Characteristics of PWMS

SEAMCAT simulations results

Co-channel

Protection distance	Unwanted interference level	Interference probability
10 km	-132 dBm	40 %
20 km	-142 dBm	15 %
30 km	-150 dBm	6 %
40 km	-157 dBm	2.5 %
50 km	-163 dBm	1.2 %
60 km	-168 dBm	0.6 %
100 km	-184 dBm	0.045 %

Table 29: Results – co-channel case

Adjacent case

Frequency offset	Unwanted interference level	Interference probability
100 kHz	-115 dBm	93.2 %
150 kHz	-160 dBm	2.8 %
200 kHz	-169 dBm	0.8 %
250 , 300, 500 kHz	-172 dBm	0.5 %

Table 30: Results – adjacent case

Conclusions for Cospas-Sarsat

In case of a co-channel deployment, **a protection distance of 100 km** is required between PWMS and Cospar Sarsat stations.

Otherwise, PWMS systems can be deployed until a 100m distance from a Cospar Sarsat station, provided **a band guard of 250 kHz** from the central frequency of the Cospar Sarsat system.

8.3 Compatibility between PWMS devices and Earth exploration satellite service

The EESS has a secondary status in this band.

This band is not listed in ITU-R Rec. RS.1166-3 [22] which provides the bands for Space Operation and there was no support to consider this case, therefore, this case is not covered.

8.4 Compatibility between PWMS devices and Aeronautical Telemetry

In this band two cases are considered:

- Co-channel case (PWMS operating in 1533-1535 MHz): Results will be similar to those given in section 6.3 (indoor).
- Adjacent band case (PWMS operating in 1535-1559 MHz): For accurate adjacent band compatibility estimation the selectivity of the receiver is needed. For simplification SEAMCAT approximates selectivity with receiver bandwidth which usually leads to some discrepancies. In actual equipment the receiver response is a product of several filters matching the signal and selectivity is different from rectangular filter. To compensate such difference actual receiver bandwidth could be extended to some equivalent bandwidth passing approximately the same amount of interfering power as actual cascade of filters. But such approximation requires the knowledge of selectivity function.

8.5 Discussion for the band 1533-1559 MHz

The conclusions given in section 7.5 are applicable for MSS therefore this band should not be identified for PWMS.

Mobile

In the band 1533-1535 MHz, 30 m separation distance should be applied.

Aeronautical

Based on the results obtained with SEAMCAT simulations it can be concluded that in rural and suburban areas the compatibility of PWMS systems with aeronautical telemetry systems may be achieved with restriction of separation distances between PWMS transmitter and Aeronautical Telemetry receiver:

- 28 km in rural and 8 km in suburban area for indoor (Thermoplane shielding) PWMS systems;
- 6 km in rural and 1.5 km in suburban area for indoor (Lime sandstone shielding) PWMS systems;

In urban area compatibility of PWMS systems with aeronautical telemetry systems is achieved.

Since the exact frequencies used by Aeronautical systems are not known, these separation distances will have to applicable over the whole frequency range used by aeronautical systems (i.e. 1492-1535 MHz for the PWMS indoor case).

9 CONCLUSIONS

The different compatibility studies realised in this report lead to the conclusions depicted in a simple way an overview of the results of these interference assessments for the different frequency bands.

Band (MHz)	**SERVICES**				
1429-1452	FIXED	MOBILE	Aeronautical Telemetry		
1452-1492	BS 1452-1479.5 MHz	BSS 1479.5-1592 MHz	Aeronautical Telemetry	Fixed	Mobile
1492-1518	FIXED	MOBILE	Aeronautical Telemetry		
1518-1525	FIXED	MOBILE	MSS (s-E)	Aeronautical Telemetry	
1525-1530	FIXED	SPACE OPERATION (s-E)	MSS(s-E)	Mobile	Aeronautical Telemetry
1533-1535	MSS (s-E)	SPACE OPERATION (s-E)	Aeronautical Telemetry	Mobile	Eess
1535-1559	MSS (s-E)				

(green)	Compatibility is achieved
(orange)	Compatibility may be achieved with mitigation techniques or restriction
(red)	Compatibility is not achieved

Taking into account the conclusions of the compatibility analyses, it was found that the following bands could be used by PWMS:

- 1452 MHz – 1477.5 MHz, in this band the following restrictions are applicable:
  - To protect FS operating in the frequency range1429 - 1452 MHz, the unwanted emissions defined in e.i.r.p of PWMS should not exceed -58 dBm in 200 kHz bandwidth
  - To protect FS/BSS operating above 1479.5 MHz, the unwanted emissions defined in e.i.r.p of PWMS in the frequency range 1479.5 – 1492 MHz should not exceed -58 dBm in 600 kHz bandwidth
  - The use of PWMS may be outdoor or indoor in this frequency range with a maximum radiated power of 50 mW (e.i.r.p)

  Administration may need to consider the following when deploying PWMS on their territory:
    - To protect FS operating in the band 1452 – 1479 MHz:
      - a separation distance of 15 km between the FS receiving station and the PWMS transmitter should be considered in a co-frequency situation. It is possible to reduce this separation distance in case of indoor usage of PWMS;
      - the PWMS emissions at the frequency used by a FS receiver should not exceed -48dBm in 200 kHz for PWMS operating at a distance from the considered FS receiver lower than the separation distance (15 km).
    - To protect ground stations in the Aeronautical Telemetry Service operating in the frequency range 1429-1492 MHz, separation distance of 36 km between aeronautical receivers and PWMS transmitter is required. In case of PWMS deployment on the territory of a neighbouring country this separation distance should not be less than 36 km to the national border (see 5.342). To protect airborne stations, separation distances are assumed to be greater.

- 1494 MHz – 1517.4 MHz, in this band the following restrictions are applicable:
  - To protect FS/Mobile/BSS operating below 1494 MHz, the unwanted emissions defined in e.i.r.p of PWMS in the frequency range 1479.5 – 1492 MHz MHz should not exceed -58 dBm in 600 kHz bandwidth
  - The use of PWMS should be limited to indoor use in this frequency range with a maximum radiated power of 50 mW (e.i.r.p)
  - To protect Fixed/Mobile/MSS operating above 1518 MHz, the unwanted emissions defined in e.i.r.p of PWMS in the frequency range 1518 – 1559 MHz should not exceed -48 dBm in 200 kHz bandwidth

Administration may need to consider the following when deploying PWMS on their territory:

- To protect FS operating in the band 1492 – 1518 MHz:
  - a separation distance of 15 km between the FS receiving station and the PWMS transmitter should be considered in a co-frequency situation;
  - the PWMS emissions at the frequency used by a FS receiver should not exceed -48dBm in 200 kHz for PWMS operating at a distance from the considered FS receiver lower than the separation distance (15 km).
- To protect ground stations in the Aeronautical Telemetry Service operating in the frequency range 1492-1535 MHz, separation distance of 28 km between aeronautical receivers and PWMS transmitter is required. In case of PWMS deployment on the territory of a neighbouring country this separation distance should not be less than 28 km to the national border (see 5.342). To protect airborne stations, separation distances are assumed to be greater.

These conclusions are valid for both analogue and digital cases. The compatibility studies between PWMS devices and Mobile Satellite service concluded that sharing is not feasible. Possible mitigation techniques (e. g. DAA) will be further investigated. When these results are available, this report should be revised or a complementary report will be developed.

ANNEX 1: SPECTRUM REQUIREMENTS FOR PWMS

In the bands IV and V, the transition from Analogue TV to Digital TV and the possible use of digital dividend by new applications (see WRC-11 Agenda Item 1.17) have eroded the availability of spectrum for PWMS. Therefore, the frequency range 1 452 MHz to 1 559 MHz ("L band") is investigated as a possible alternative band for PWMS. It should be noted that this resource will only compensate for the reduced resources brought about by the “Digital Dividend” (790 to 862 MHz). Any L band resources made available cannot substitute for the future UHF usage of PWMS.

Estimation of the spectrum requirement in the L band

An initial estimate of the typical L-band resource requirement for PWMS is as follows:

- 20 standard (16 bit) or 16 HD-sound microphones (28 to 32 bit)
- 20 IEM back links

It also noted that for operation in a single band, 100 MHz of IM-free spectrum would be required. This estimate is based on the amount of spectrum that will no longer be available after Digital Switch Over.

Rationale

Figure 6 shows the required spectrum spread against the numbers of channels needed in operation.

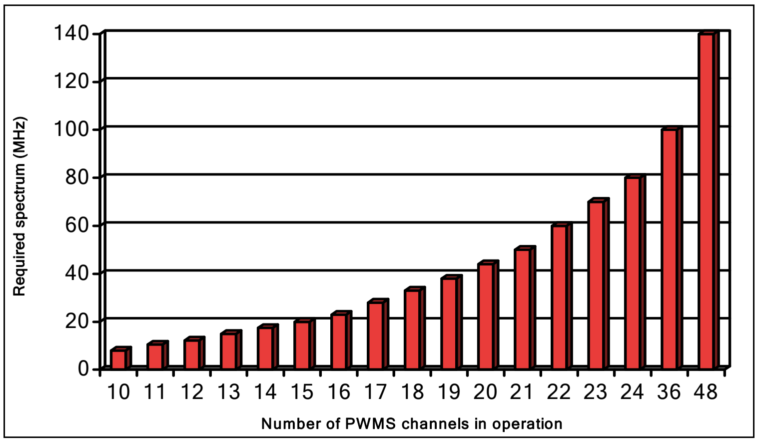


Table A1.1: Spectrum spread against the numbers of channels required

40 channels require just over 100 MHz of spectrum, but in practice, and for simplicity, this can be rounded down to 100 MHz. This is not a continuous block of spectrum, but rather the amount of spectrum over which the channels are spread. This model has been developed over many years, based on practical, real-life, deployments.

The various PWMS channels need to be spread out to minimise IM products and in the process. This principle is explained below, using the example of a 20 channel system for clarity.

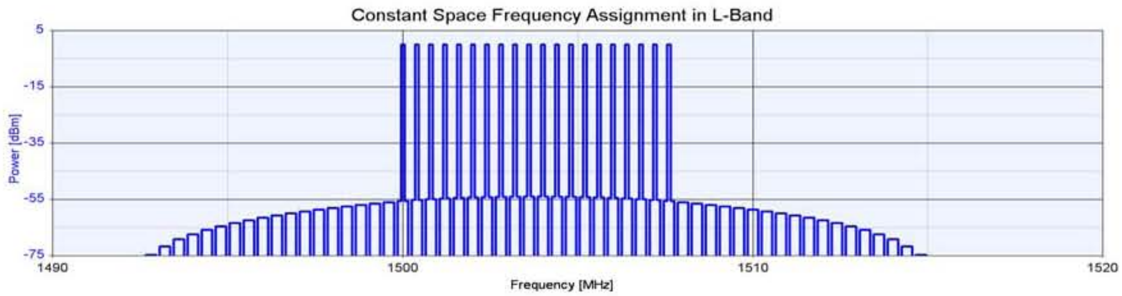


Figure A1.2: 20 channel system in a compact band, using equal spacing

This figure was produced using an industry-standard system simulation application. This application is used in real-life to plan PWMS channel plans for PWMS installations.

If the 20 channels are placed close together (see figure 9) IM products cumulate to produce a significant increase in background noise and interference – as much as 20dB in the centre of the frequency range. This IM interference spreads out to around 15 MHz beyond the edges of the frequency range.

If the PWMS channels can be spread out, the intermodulation products can be distributed so that they are minimised and do not accumulate (see Figure A1.3 where the blue curve represents the PWMS channels.).

In addition, Figure 9 shows the corresponding deployment of PWMS in the gaps between fixed link emissions. It should be emphasised that the PWMS deployment is flexible and can be adapted to fit around whatever protected emissions are operating in the band.

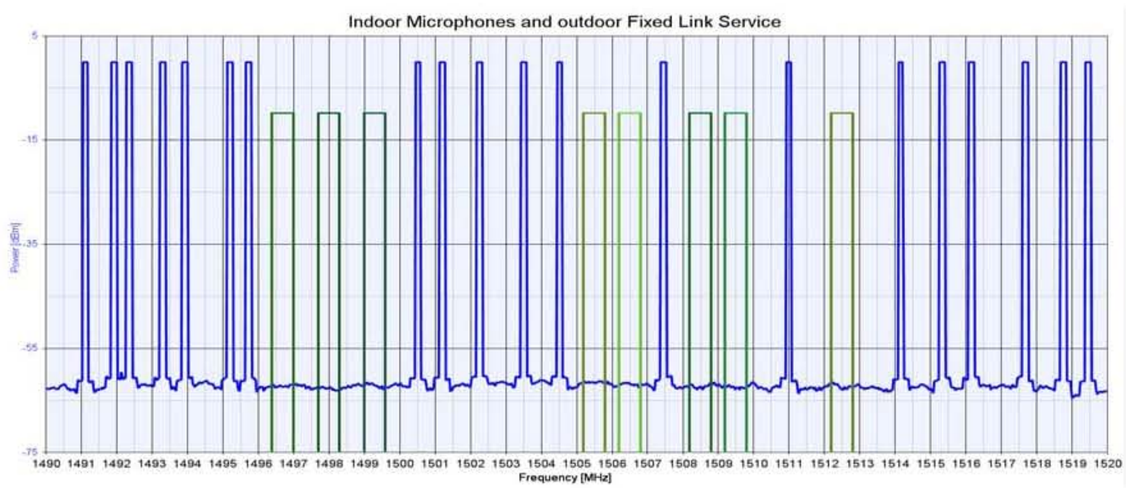


Figure A1.3: Typical 20 channel PWMS deployment showing co-existence with other services

This example showed a 20 channel deployment in 30 MHz for clarity. The same principle applies to, for example, a 40 channel deployment in 100 MHz.

ANNEX 2: SEAMCAT ANALYSIS - CO-CHANNEL CASE – INDOOR CASE 6DB WALL LOSS

This annex was developed for information in order to assess the impact of a separation distance of 10 km for the indoor case (6dB wall loss)

Victim and interfering links parameters

Victim link parameters	
Frequency	1500 MHz
Reception Bandwith	25 kHz or 2000 kHz
I/N	-10dB
Noise Floor (-110 dBm/MHz)	-126 dBm (for the 25kHz reception BW) -107 dBm (for the 2000kHz reception BW)
Antenna height	20m
Antenna peak gain	13 dBi
Antenna horizontal pattern	See blue line Figure 7
Interferer link parameters	
Frequency	1500 MHz
Power supplied	15 dBm
Antenna	Height : 2m Azimuth : 0° Elevation : 0° Peak gain : 2.1 dB Vertical pattern of figure 3 (right)
Interferer → victim path	Transmitter density : 0.1/km2 Number of active transmitters : 1 or 10 (see results) Probability of transmission : 1 Activity time : 1 Protection distance : 10 km
Interferer → victim path model	Extended Hata, rural, indoor-outdoor attenuation 6 dB

Table A2.1: Scenario 1 SEAMCAT Parameters

Simulation results

	N=1 interferer		N=10 interferers	
	200 kHz	600 kHz	200 kHz	600 kHz
FS with 25 kHz bandwidth				
Mean iRSS (std)	-138.7 dBm (std : 11,6)	-143.4 dBm (std : 11,6)	-120.5 dBm (std : 7,2)	-125.3 dBm (std : 7,3)
Interference probability (with I/N criterion)	40%	25%	99.8%	96%
FS with 2000 kHz bandwidth				
Mean iRSS (std)	-129.6 dBm (std : 11,7)	-134.4 dBm (std : 11,5)	-111.6 dBm (std : 7,3)	-116,4 dBm (std : 7,2)
Interference probability (with I/N criterion)	14.4%	7.1%	75.6%	48%

Table A2.2: Results of simulations

ANNEX 3: PWMS MEASUREMENT EXERCISES AT 1.5 GHz

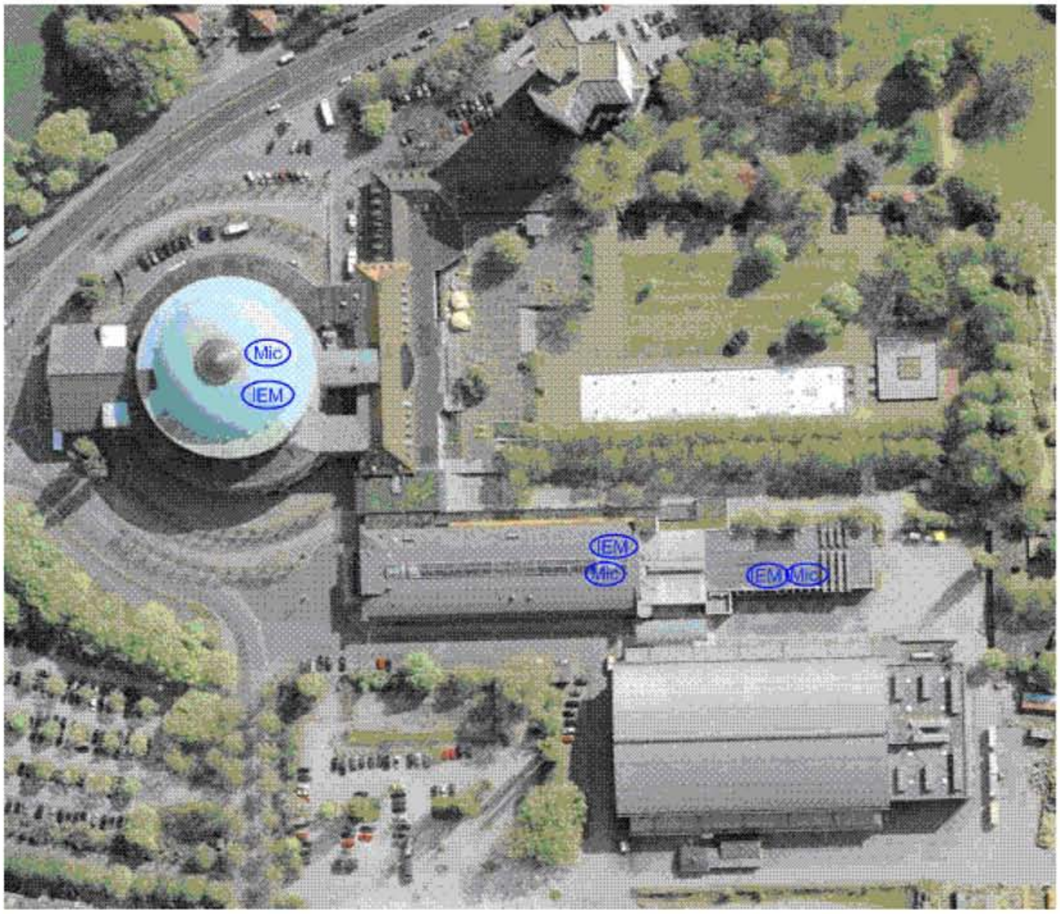
Introduction

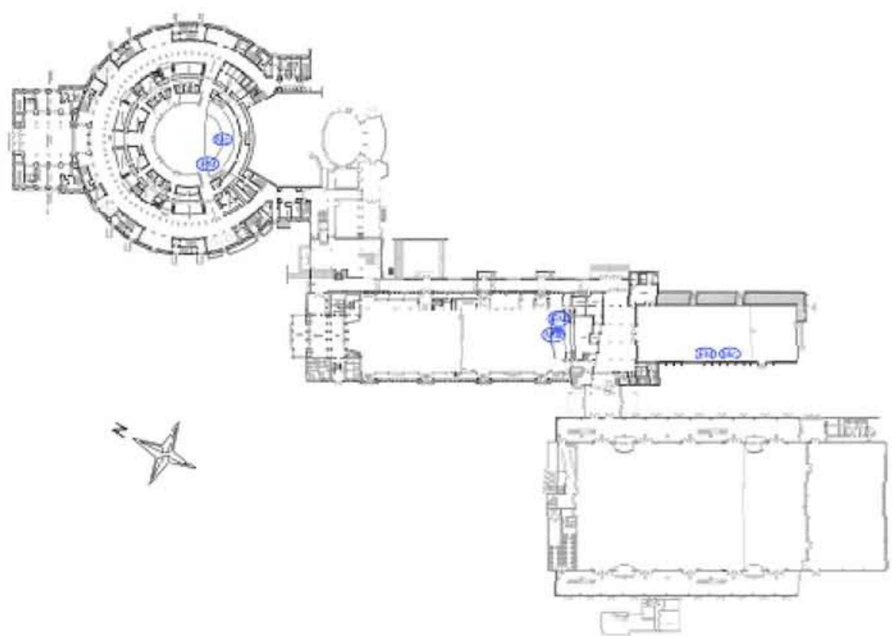
This annex provides the results of measurement of PWMS emissions at 1.5 GHz. Wireless microphone and IEM, in typical sport and theatre installations using L-Band frequencies were tested.

Part A provides results of measurement using the example of a typical conference installation undertaken in Hanover and Part B provides results of measurements undertaken in Vienna in an open stadium and in a theatre.

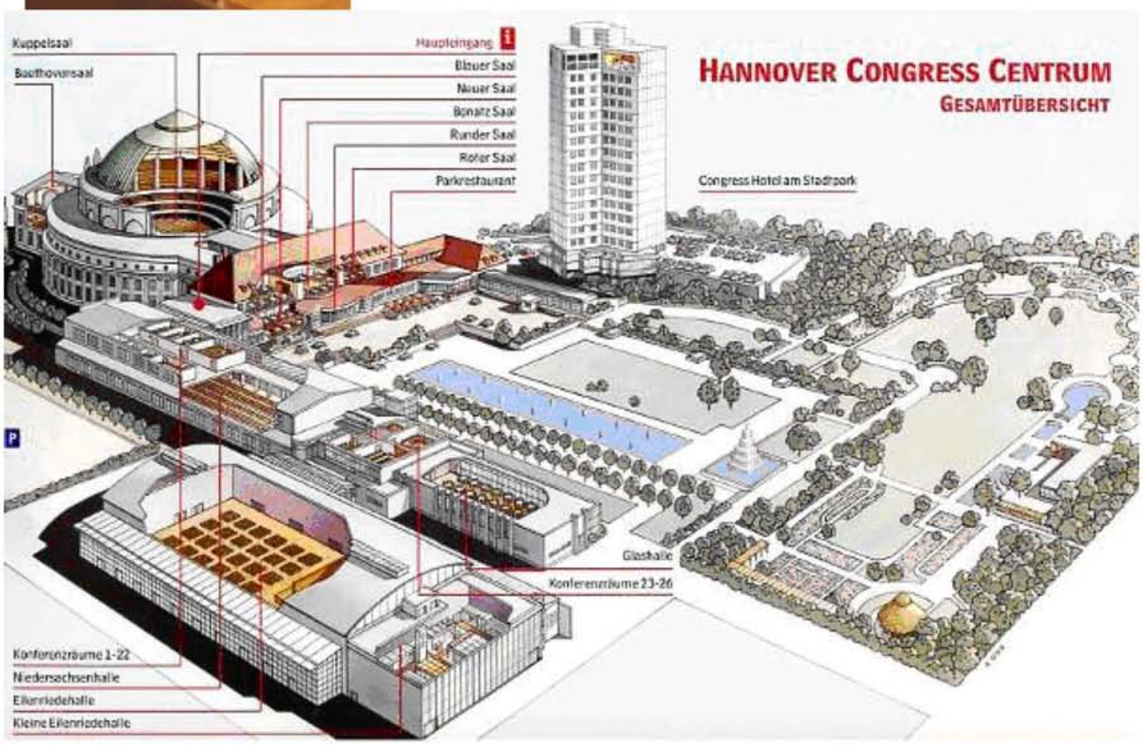
Part A: PWMS measurement exercise at L-Band frequencies in Hanover (4th February 2008)

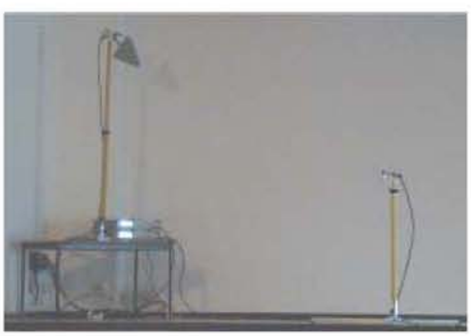
Position of Microphone and IEM test installation





Wireless microphone and IEM set up at Kuppelsaal, Niedersachsenhalle and Glashalle





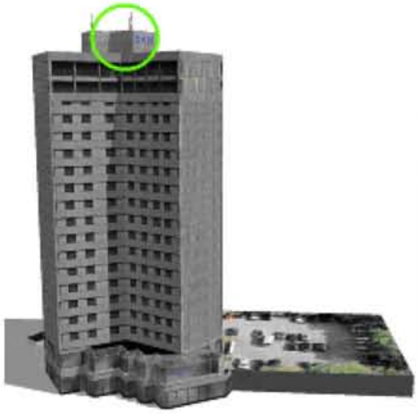
IEM transmitter and Hand Held wireless microphone configurations (see the description in Part B)

Measurement set up on top floor of hotel

- RF spectrum analyser FSQ03
- Laptop, software 'UHF Recorder'
  including L-Band option (DKE-AK731.0.8)

- L-band-antenna LAT54 mounted on microphone stand, directed to Glashalle

LAT54 at 1500 MHz



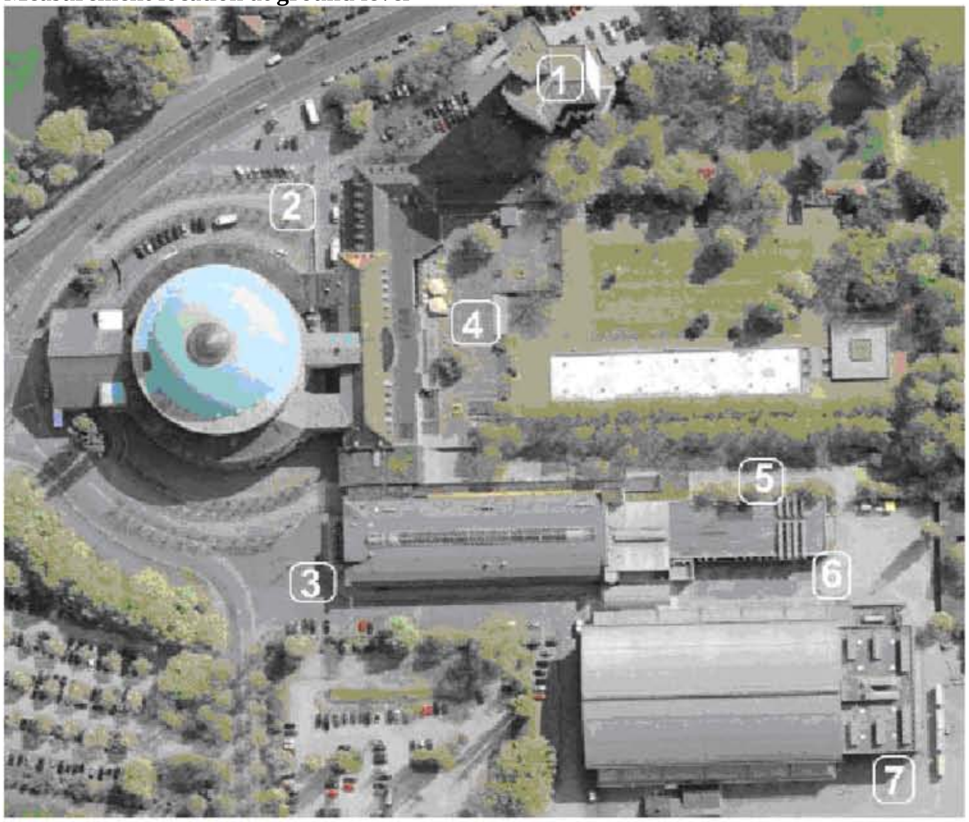
Measurement antenna set up on mid-height floor of hotel

Mobile measurement set up

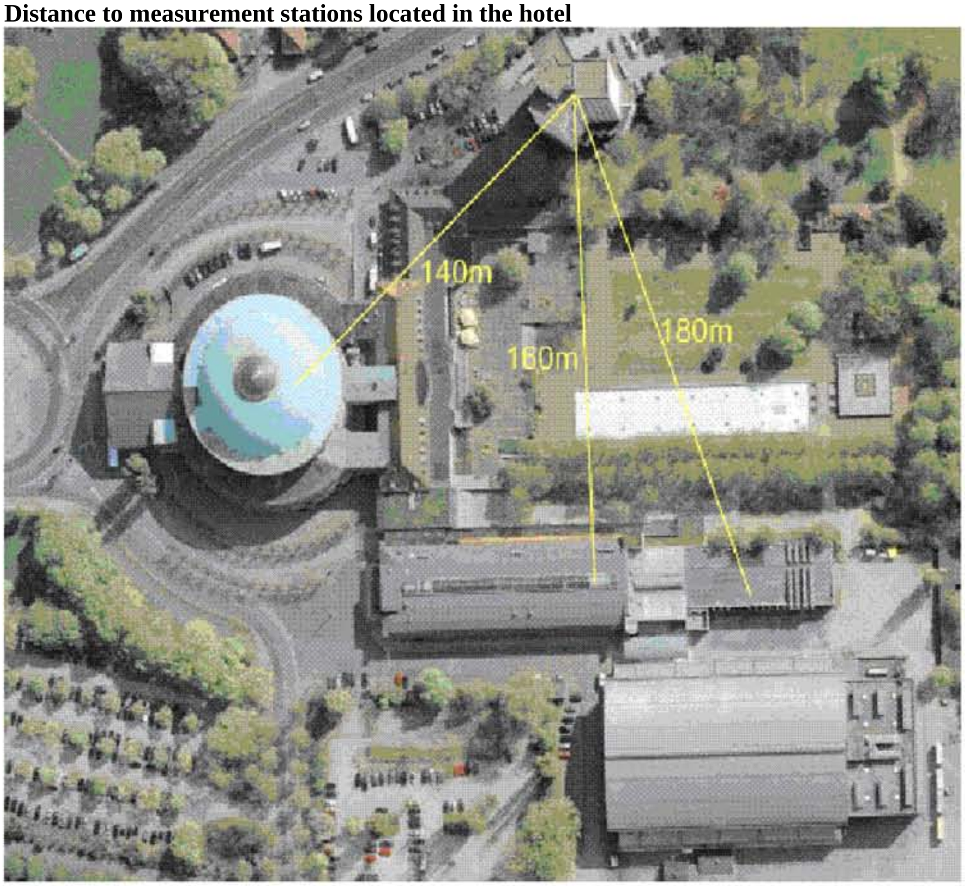
- RF network and spectrum analyzer ZVL06
- Laptop, software 'UHF Recorder' including L-Band option (DKE-AK731.0.8)
- Omni directional ground plane antenna
- External battery including DC/DC converter

Mobile measurement set up in front of Glashalle

Measurement location at ground level



Distance to measurement stations located in the hotel



Description of measurement setup at RF receiving locations

1. Hotel Location

The directional antenna is pointed at Glashalle. The measured RF levels show the maximum interference level for a RF link in the main link direction Glashalle. Building walls made out of standard glass, no metallic coating, distance to RF measurement receiver is 180m, identical antenna polarization. The table shows the maximum levels measured over a continuous time period.

2. Location of mobile measurement setups (indoor and outdoor)

The antenna is adjusted for maximum field strength and the measurements were recorded in the table below.

Measurement results: Wireless microphone transmitter and IEM transmitter

Receiver location / Transmitter location	Maximum receiving level [dBm]													
	1		2		3		4		5		6		7	
	f1	f2	f1	f2	f1	f2	f1	f2	f1	f2	f1	f2	f1	f2
Kuppelsaal	**n/a.**	**n/a.**	**-80**	**-100**	**-87**	**-92**	**n/a**	**-101**	**n/a**	**n/a**	**n/a.**	**-105**	**n/a**	**-105**
Glashalle	**-86**	**-78**	**n/a**	**n/a.**	**-95**	**-105**	**-76**	**-88**	**-63**	**-63**	**-70**	**-67**	**-105**	**-105**
Niedersachenhalle	**-90**	**-98**	**n/a**	**-103**	**-88**	**-90**	**-91**	**-106**	**-106**	**-107**	**-94**	**-104**	**-111**	**-106**

Table results rounded to integer values
n/a = Not applicable, i.e. receiving level below minimum receiving level of receiving measurement equipment (-112dBm)
f1, f2 = frequencies 1485 / 1515 MHz
Antenna amplification = 10dBi antenna used at hotel / 0dBi mobile antenna

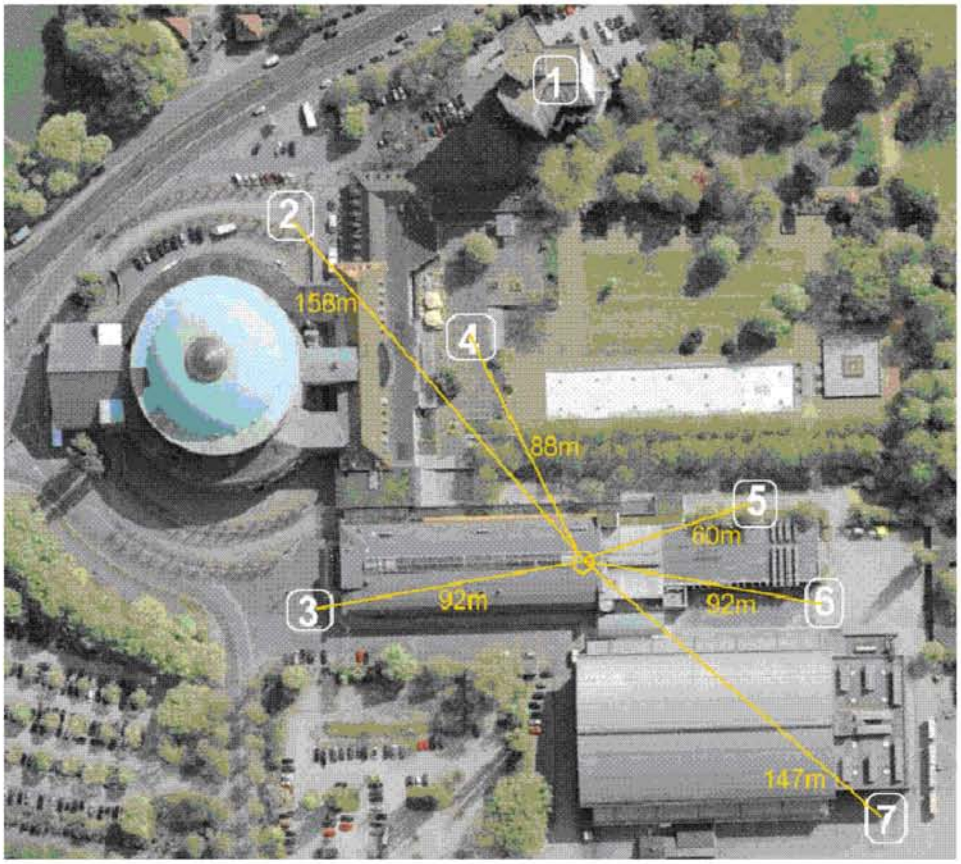
Estimation of building attenuation

Measurement path	Path length	Receiving level based on free space path loss formula	Measured receiving level	Calculated attenuation by building
Hotel to Glashalle	**180 m** *1	**-75 dBm**	**-86 dBm**	**11 dB**
Hotel to Niedersachsenhalle	**160 m** *1	**-74 dBm**	**-90 dBm**	**16 dB**
Kuppelsaal to test point 3	**89 m**	**-61 dBm**	**-88 dBm**	**27 dB**

Table results rounded to integer values
*1 antenna gain measurement antenna used at Hotel included

Comparison of free space path loss calculation with measured values

1. **Niedersachsenhalle**



Estimation of additional path loss due to surrounding buildings (f1)

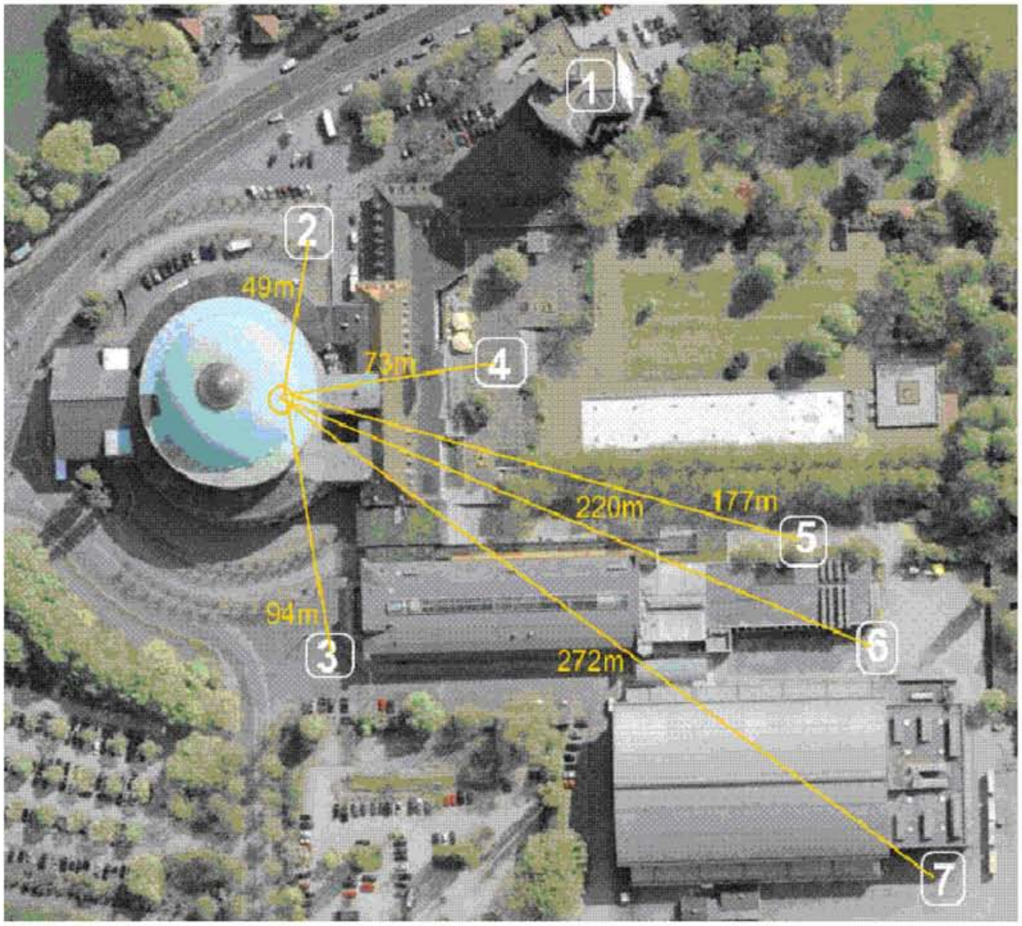
Path calculated from Niedersachsenhalle to outdoor test points @1500 MHz

Path to test point	Path length [km]	Micro Antenn. height [m]	Used PT [dBm]	Mobil Antenn. height [m]	Meas. RI [dBµV]	Calcul. RI [dBm]	Used AG [dBi]	Used CL [dB]	Calcul. PR [dBm]	Calcul. PL [dB]	Free space PL [dB]	Extended Hata Path Loss [dB] Open / Suburb. / Urban		
2 (Note 1)	0,158	2,5	17	1,5	<-8,0	<-115	0,0	1,6	-113,4	>96,4	79,9	94,8	114,3	125,7
3	0,092	2,5	17	1,5	19,0	-88,0	0,0	1,6	-86,4	69,4	75,2	85,5	103,3	113,6
4	0,088	2,5	17	1,5	16,0	-91,0	0,0	1,6	-89,4	72,4	74,9	84,3	101,1	110,9
5	0,060	2,5	17	1,5	1,0	-106,0	0,0	1,6	-104,4	87,4	71,5	75,2	83,9	88,9
6	0,092	2,5	17	1,5	13,0	-94,0	0,0	1,6	-92,4	75,4	75,2	85,5	103,3	113,6
7	0,147	2,5	17	1,5	-4,0	-111,0	0,0	1,6	-109,4	92,4	79,3	93,7	113,2	124,6

Note 1: Receiving level below minimum receiving level of receiving measurement equipment. Therefore -8dBµV is used.

f1 = 1485 MHz

2. Kuppelsaal



Estimation of additional path loss due to surrounding buildings (f1)

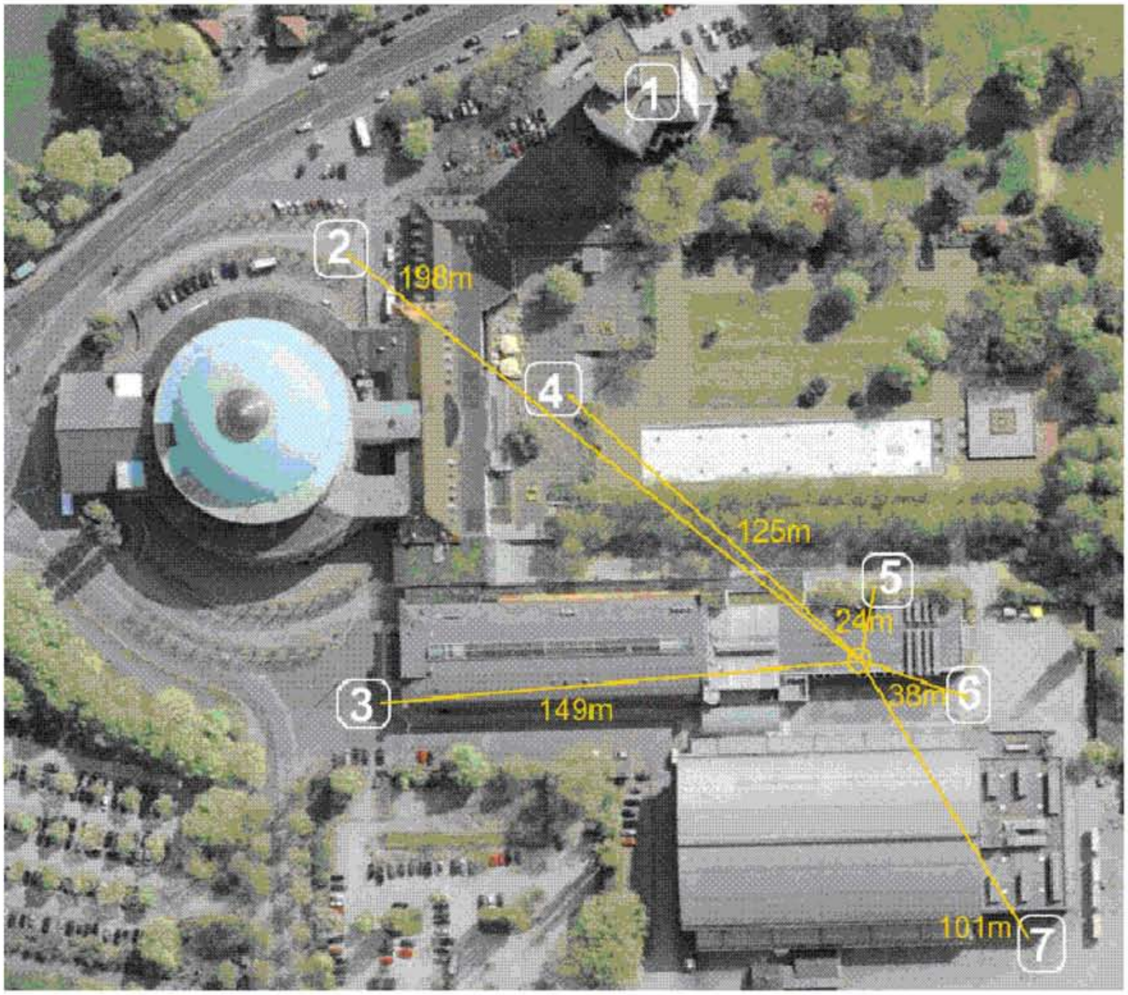
Path calculated from Glashalle to outdoor test points @1500 MHz

Path to test point	Path length [km]	Micro Anten. height [m]	Used PT [dBm]	Mobil Anten. height [m]	Meas. RI [dBµV]	Calcul. RI [dBm]	Used AG [dBi]	Used CL [dB]	Calcul. PR [dBm]	Calcul. PL [dB]	Free space PL [dB]	Extended Hata Path Loss [dB] Open / Suburb. / Urban		
2 (Note 1)	0,198	2,5	17	1,5	<-8,0	<-115	0,0	1,6	-113,0,4	>96,4	81,9	98,2	117,7	129,2
3	0,149	2,5	17	1,5	12,0	-95,0	0,0	1,6	-93,4	76,4	79,4	93,9	113,4	124,8
4	0,125	2,5	17	1,5	31,0	-76,0	0,0	1,6	-74,4	57,4	77,9	91,2	110,8	122,1
5	0,024	2,5	17	1,5	44,0	-63,0	0,0	1,6	-61,4	44,4	63,6	63,5	63,5	63,5
6	0,038	2,5	17	1,5	37,0	-70,0	0,0	1,6	-68,4	51,4	67,6	67,5	67,5	67,5
7	0,101	2,5	17	1,5	2,0	-105,0	0,0	1,6	-103,4	86,4	76,1	87,9	107,5	118,9

Note 1: Receiving level below minimum receiving level of receiving measurement equipment. Therefore -8dBµV is used.

f1 = 1485 MHz

Glashalle



Estimation of additional path loss due to surrounding buildings
Path calculated from Kuppelsaal to outdoor test points @1500 MHz

Path to test point	Path length [km]	Micro Anten. height [m]	Used PT [dBm]	Mobil Anten. height [m]	Meas. RI [dBμV]	Calcul. RI [dBm]	Used AG [dBi]	Used CL [dB]	Calcul. PR [dBm]	Calcul. PL [dB]	Free space PL [dB]	Extended Hata Path Loss [dB] Open / Suburb. / Urban		
2	0,049	2,5	17	1,5	27,0	-80,0	0,0	1,6	-78,4	61,4	69,8	71,3	75,6	78,2
3	0,094	2,5	17	1,5	20,0	-87,0	0,0	1,6	-85,4	68,4	75,4	86,1	104,3	114,9
4 (Note 1)	0,073	2,5	17	1,5	<-8,0	<-115	0,0	1,6	-113,4	>96,4	73,2	79,6	92,5	99,9
5 (Note 1)	0,177	2,5	17	1,5	<-8,0	<-115	0,0	1,6	-113,4	>96,4	80,9	96,5	116,1	127,5
6 (Note 1)	0,220	2,5	17	1,5	<-8,0	<-115	0,0	1,6	-113,4	>96,4	82,8	99,8	119,4	130,8
7 (Note 1)	0,272	2,5	17	1,5	<-8,0	<-115	0,0	1,6	-113,4	>96,4	84,7	103,0	122,5	134,0

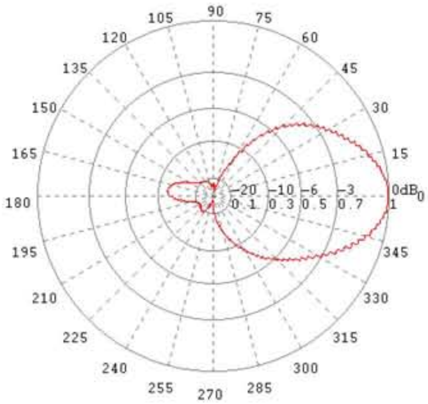
Note 1: Receiving level below minimum receiving level of receiving measurement equipment. Therefore -8dBμV is used.

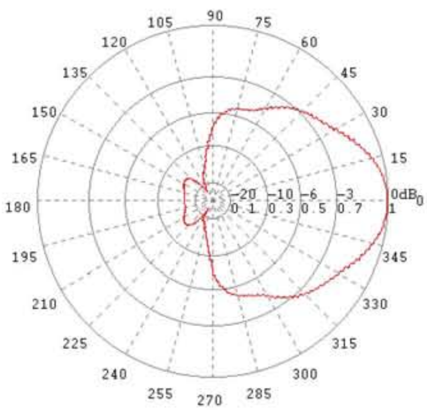
f1 = 1485 MHz

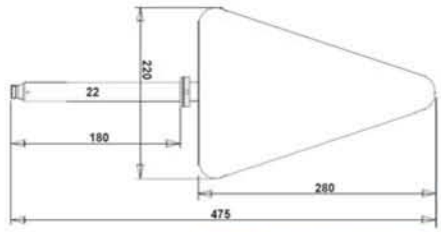
Part B: on PWMS measurement exercise at L-Band frequencies in Vienna
(13^{th} and 14^{th} of February 2008)

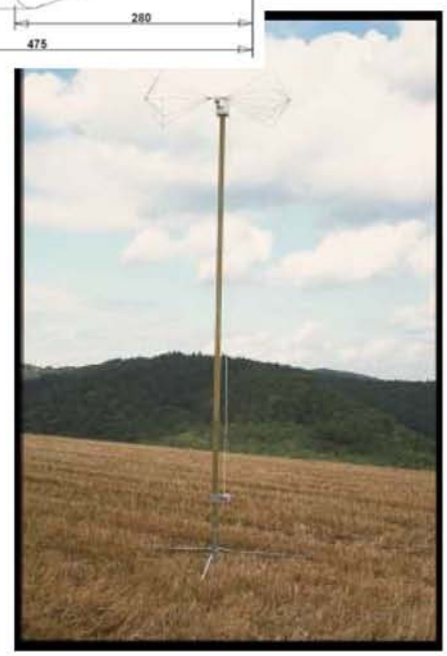
IEM transmitter configuration

1. Directional antenna: Schwarzbeck ESLP9145,
→ Gain@1.4-1.5GHz~6.3dBi





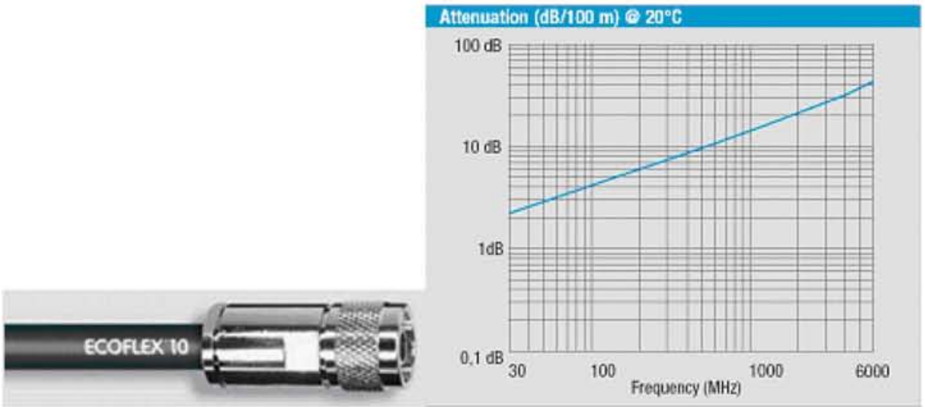




Antenna was mounted
on a fibreglass mast,
Schwarzbeck AM9104

2. Signal generator: Rohde & Schwarz SML02 and SMB 100A
→ Output power up to 30dBm
→ analogue modulation: AF tone = 1kHz, +/-40kHz deviation
→ Manufactory calibration 2007

3. 10/20m RF cable: SSB electronic Ecoflex 10
→ Loss@1.5GHz~1.5/3dB



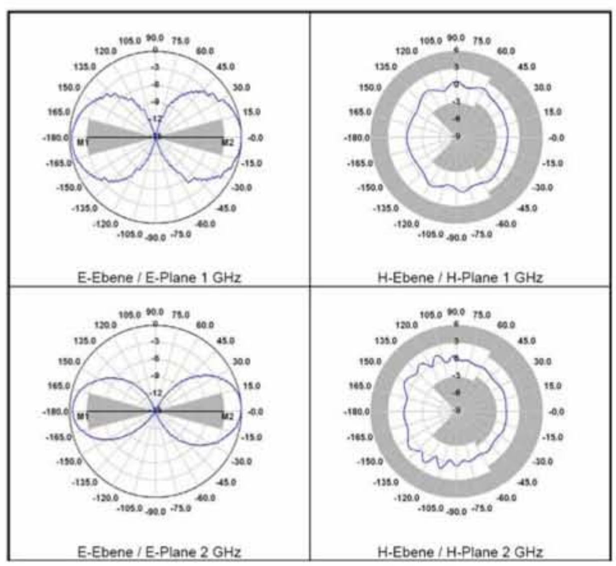
Hand held & instrument wireless microphone configuration

1. Signal generator: Rohde & Schwarz SML02
→ Output power up to 19dBm
→ analogue modulation: AF tone = 1kHz, +/-40kHz deviation
→ Manufactory calibration 2007

2. 10/20m RF cable: SSB electronic Ecoflex 10
→ Loss@1.5GHz~1.6 / 3.4dB

3. Dipole (omnidirectional) antenna, Schwarzbeck SBA 9113
→ Gain@1.5GHz = -0.22dBi

Antenna was mounted on a microphone stand



Calibration and test equipment:

Network and spectrum analyzer combination, Rohde & Schwarz ZVL6
→ Manufactory calibration 2007

Principle calibration of radiated transmit power

1. IEM antenna emulation (1515MHz, 50mW e.i.r.p)

10.6dBm

Generator 14dBm	20m coaxial cable cable loss ~ 3.4dB @ 1.5GHz	Antenna gain ~ 6.4dBi @ 1.5GHz	Radiated power ~17dBm e.i.r.p.

2. Hand held microphone and instrument microphone emulation (1495MHz, 50mW e.i.r.p)

Generator 18.8dBm	10m coaxial cable cable loss ~ 1.6dB @ 1.5GHz	Antenna gain ~ -0.2dBi @ 1.5GHz	Radiated power ~17dBm e.i.r.p.

17.2dBm

3. Hand held microphone and instrument microphone emulation (1500MHz, 100mW e.i.r.p)

Generator 21.8dBm	10m coaxial cable cable loss ~ 1.6dB @ 1.5GHz	Antenna gain ~ -0.2dBi @ 1.5GHz	Radiated power ~20dBm e.i.r.p.

20.2dBm

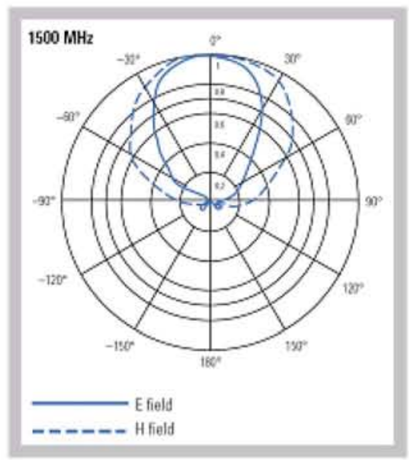
Note:
100mW used to increase signal strength above the noise level at remote locations. This power level will not be used in deployed PWMS systems.

Test equipment to measure the outdoor field strength (supported by BMVIT)

Parameter of car antenna HL040 (HL015)

For obtaining broadband characteristics, the HL040 antenna has a log periodic dipole structure.
The antenna was mounted for mobile use, on a crank-type telescopic mast.

The interpolated antenna gain @ 1500 MHz is about 5.6 dBi.



Principle of field strength conversion to receiving power level

P[dBm] = E[dBµV/m] - AF[dB] - 107

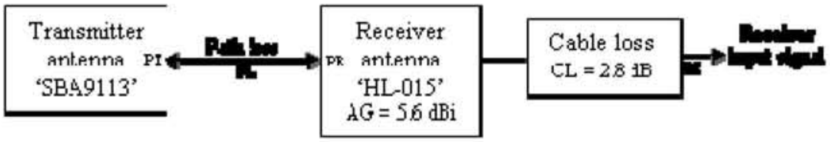
P [dBm] - Receiver input power level generated by a 50 Ω dipole
E [dBµV/m] - Radio frequency field strength
AF [dB] - Antenna factor including cable loss (e.g. Dipole: ~31 dB@1500MHz)

Path loss calculation using free space path loss formula

PL[dB] = 32.45 + 20 * log(d[km]) + 20Log(f[MHz])

d [km] - Distance
f [MHz]- Frequency

Path loss calculation using measurement results



PL[dB] = PT[dBm] – PR[dBm]   PR[dBm] = RI[dBm] - AG[dB] + CL[dB]

AG [dBd] - Receiver antenna gain (referred to an isotropic antenna)
CL [dB] - Receiver cable loss
PL [dB] - Free space path loss
PR [dBm] - Receiver antenna input signal
PT [dBm] - Effective isotropic radiated power (e.i.r.p)
RI [dBm] - Receiver input signal

Path loss calculation using 'Extended Hata method'

Results were calculated with the SEAMCAT simulator (see appendix).

For additional information refer: http://www.seamcat.org/xwiki/bin/view/Seamcat/extended_hata_model

Locations of the transmitting antennas

Vienna Volksoper

The Vienna Volksoper (Volksoper Wien or Vienna People's Opera) is a major opera house in Vienna, Austria..
Coordinate 48° 13' 29" N, 16° 20' 59" E Decimal 48.224722°, 16.349722°

Location Volksoper   Map supported by www.viamichelin.com

Blue colored measurement points with signal below receiver noise level (-92dBm)

Microphone setup inside the theatre

Microphone antennas (height~1.5m)

IEM antenna (height~4m)

Top view on test setup

Test setup outside the theatre

Rx Position 1

2

3

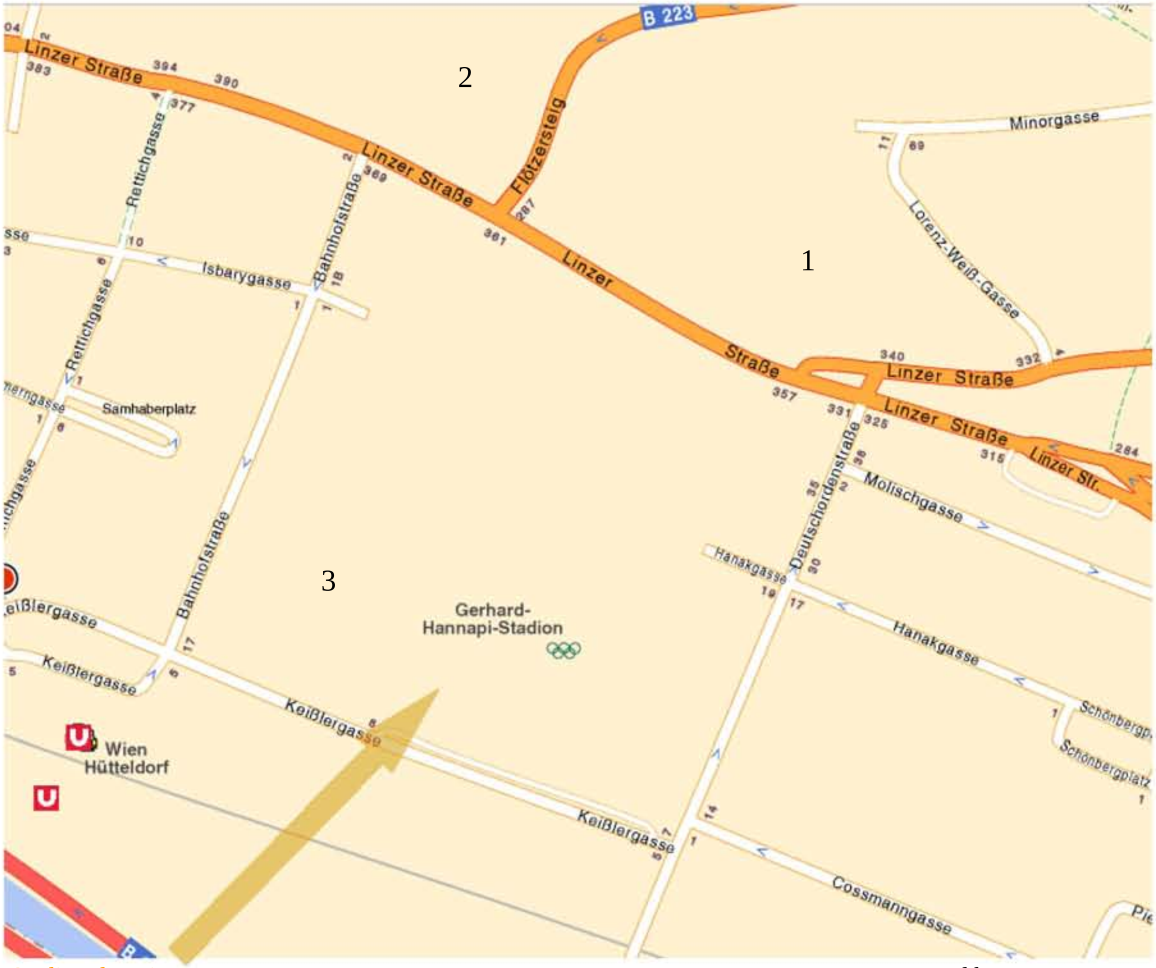
Rx Position	**Distance to microphones [m]**	**Calculated free space RX level** (min to max) [dBµV/m]	**Measured additional path loss** (min to max) [dB]	**Antenna height [m]**	**Outdoor field strength [dBµV/m] / Receiver level [dBm @ 50 Ω dipole]**		
					1495 MHz	**1500 MHz**	**1515 MHz**
1	82[1)]	86 to 89[1)]	27 to 33[1)]	2.5	63 / -75	62 / -76	54 / -84
2	45[1)]	91 to 94[1)]	13 to 21[1)]	2.5	73 / -65	81 / -57	70 / -68
3	60[1)]	88 to 91[1)]	24 to 32[1)]	8.0	55 / -83	65 / -73	54 / -84

Table calculation and measurement results rounded to integer values
[1)] Source: BMViT Report, 14th February 2008

Gerhard Hanappi Stadion

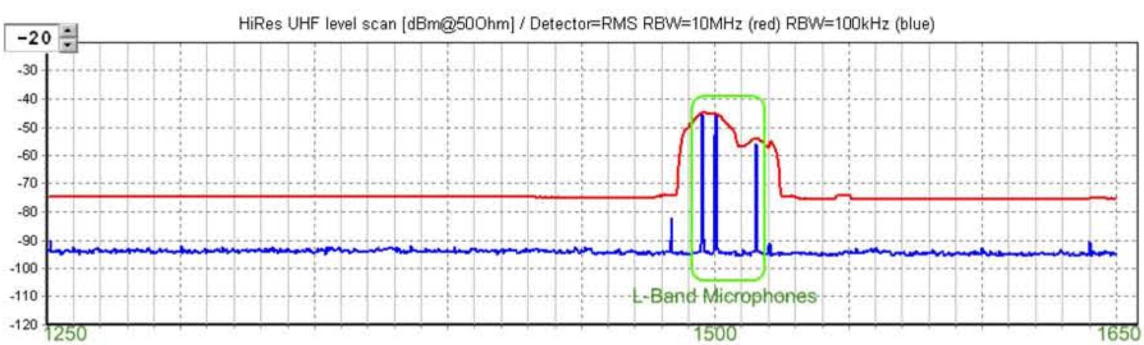
The Gerhard-Hanappi Stadion is a football stadium in Hütteldorf, in the west of Vienna, Austria. (Wikipedia)

Coordinate 48° 11' 52" N, 16° 15' 55" E Decimal 48.197778°, 16.265278°



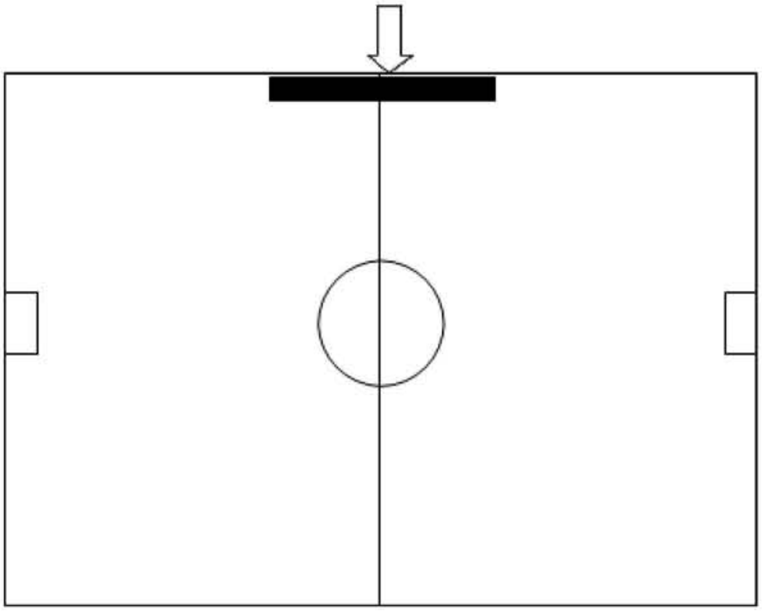
Stadium location   Map supported by
www.viamichelin.com

Spectrum occupation measured inside the Gerhard-Hanappi Stadion



Microphone setup inside the stadium

650.1MHz/50mW: Wireless Microphone
790MHz/50mW: Wireless Microphone
861.9MHz/50mW: Wireless Microphone
1495MHz/50mW: Dipole, antenna height~1.5m
1500MHZ/100mW Dipole, antenna height~1.5m
1515MHz/50mW: Directional Antenna (auditorium). h~1.5m



Test setup outside the stadium




Rx Position 1 2 3

Rx Position	Distance to microphones [m]	Calculated free space RX level (min to max) [dBµV/m]	Measured additional path loss, (min to max) [dB]	Antenna height [m]	Outdoor field strength [dBµV/m] / Receiver level [dBm @ 50 Ω dipole] 1495 MHz	1500 MHz	1515 MHz
1	205[1)]	78 to 81[1)]	17 to 23[1)]	2.5	58 / -80	63 / -75	55 / -83
2	367[1)]	73 to 76[1)]	26 to 28[1)]	5.0	47 / -91	49 / -89	47 / -91
3	205[1)]	78 to 81[1)]	25 to 30[1)]	8.0	49 / -89	56 / -82	48 / -90

Table calculation and measurement results rounded to integer values
[1)] Source: BMViT Report, 13th February 2008

Long distance field strength monitoring

The microphone field strength level were recorded by the Austrian Radio Monitoring System 'Funküberwachung'(located at Krapfenwaldgasse and Satzberg).

Results of Satzberg monitoring station:

Distance to microphones (estimated value) **[m]**	**Calculated free space path loss** (1500MHz) **[dB]**	**Calculated free space RX level** (Dipole AF=31) **[dBm] / [dBµ/m]**	**Measured additional path loss [dB]**	Satzberg		**Outdoor field strength [dBµV/m]**
				Antenna height [m]	**Height above see level [m]**	**1500 MHz**
4450	109	-92 / 46	28 [1)]	22	323	18

[1)] Includes antenna factor of Satzberg antenna (No further details available)

There was no microphone signal reception at Krapfenwaldgasse monitoring station.

Results of Krapfenwaldgasse monitoring station:

Distance to microphones (estimated value) **[m]**	**Calculated free space path loss** (1500MHz) **[dB]**	**Calculated free space RX level** (Dipole AF=31) **[dBµV/m] / [dBm]**	**Measured additional path loss [dB]**	**Krapfenwaldgasse**		**Outdoor field strength [dBµV/m]**
				Antenna height [m]	**Height above see level [m]**	**1500 MHz**
2240	103	-86 / 52	27 [1)]	25	323	25

[1)] Includes antenna factor of antenna at Krapfenwaldgasse (No further details available)

There was no microphone signal reception at Satzberg monitoring station.

Appendix 1: Comparison with the Extended HATA Propagation Model

1st Volksoper (indoor scenario)

RX Position	Path lenght [km]	Micro Antenna height [m]	Used PT [dBm]	Car Antenna height [m]	Measured RI [dBµV]	Calculated RI [dBm]	Used AG [dBi]	Used CL [dB]	Calculated PR [dBm]	Calculated PL [dB]	Free space PL [dB]	Ex-Hata PL open [dB]	Ex-Hata PL suburban [dB]	Ex-Hata PL urban [dB]
1	0,082	1,5	20	2,5	32,6[2)]	-74,4	5,6	2,8	-77,2	97,2[1)]	74,2	88,9[3)]	100,2[3)]	109,1[3)]
2	0,045	1,5	20	2,5	50,9[2)]	-56,1	5,6	2,8	-58,9	78,9[1)]	69,0	71,4[3)]	73,9[3)]	75,4[3)]
3	0,060	1,5	20	8,0	35,2[2)]	-71,8	5,6	2,8	-74,6	94,6[1)]	71,5	75,3[3)]	82,9[3)]	87,9[3)]
4[4)]	0,150	1,5	20	8,0	<15,0	<-92,0	5,6	2,8	<-94,8	>114,8	79,5	83,9[3)]	103,5[3)]	114,8[3)]
5[4)]	0,250	1,5	20	8,0	<15,0	<-92,0	5,6	2,8	<-94,8	>114,8	83,9	91,7[3)]	113,3[3)]	122,6[3)]

Calculation frequency = 1500 MHz
1) Including theatre wall attenuation
2) Source: BMViT Report, 14th February 2008
3) Results calculated with SEAMCAT
4) RX Positions without significant signal reception. Therefore as reception level the receiver signal sensitivity of -92 dBm is used.

2nd Gerhard Hanappi Stadion (semi outdoor scenario)

RX Position	Path lenght [km]	Micro Antenna height [m]	Used PT [dBm]	Car Antenna height [m]	Measured RI [dBµV]	Calculated RI [dBm]	Used AG [dBi]	Used CL [dB]	Calculated PR [dBm]	Calculated PL [dB]	Free space PL [dB]	Ex-Hata PL open [dB]	Ex-Hata PL suburban [dB]	Ex-Hata PL urban [dB]
1	0,205	1,5	20	2,5	33,8[2)]	-73,2	5,6	2,8	-76,0	96,0[1)]	82,2	98,8[3)]	118,3[3)]	129,7[3)]
2	0,367	1,5	20	5,0	19,2[2)]	-87,8	5,6	2,8	-90,6	110,6[1)]	87,3	101,7[3)]	121,2[3)]	132,6[3)]
3	0,205	1,5	20	8,0	26,1[2)]	-80,9	5,6	2,8	-83,7	103,7[1)]	82,2	88,7[3)]	108,2[3)]	119,6[3)]

Calculation frequency = 1500 MHz
1) Including multi path effects (e.g. reflections)
2) Source: BMViT Report, 13th February 2008
3) Results calculated with SEAMCAT

Appendix 2: Volksoper Measurement report provided by BMViT, Austria

RX Position 1:

Messbericht

Datum	13.Februar 2008	Lfd. Nr.:	Standort 1	Dienststelle:	FÜ-Wien
Messort:	1140 Wien, Linzerstraße			Koordinaten:	48N11 58 16E16 04

(das Datum kann automatisch durch Drücken des "Datum" Button befüllt werden)

Messmittel:

X	EMI-Messempfänger	ESCI
X	Richtantenne	HL-015
X	Mikrowellenkabel	10 m

Referenz/Bemerkungen zu den nachstehenden Messungen:

Standort der Funkmikrofone:
Gerhard Hanappi Stadion 48N11 51,6 16E15 57,7

Messantennenhöhe = 2,5 m
Polarisation = vertikal

			Messwerte										Dämpfung		Faktoren		
	Uhrzeit hh:mm	Messfrequenz in MHz	Senderstandort (ME=Messentfernung)		Mess-bandbreite in kHz	Messwert in dBµV an 50 Ohm (mit Umrechnung auf Feldstärke)							max. zu erwartende Feldstärke bei Freiraumausbreitung in dBµV/m	Zusatzdämpfung Übertragungsstrecke (bei Avg Messwert) in dB	Kabel Dämpfung in dB	Antennen-Faktor in dB	Bild-Dokumentation
						Peak		Avg		RMS							
			EIRP des Senders in dBm	ME in m		U dBµV	E dBµV/m	U dBµV	E dBµV/m	U dBµV	E dBµV/m						
1		1.495,0	17	205	1000			28,3	57,9	28,4	58,0	77,7	19,8	2,8	26,8	Bild 001
2		1.500,0	20	205	1000			33,8	63,4	33,8	63,4	80,7	17,3	2,8	26,8	Bild 004
3		1.515,0	17	205	120			25,0	54,6	25,0	54,6	77,7	23,1	2,8	26,8	Bild 006
4		650,1	17	205	1000			35,4	56,6	35,4	56,6	77,7	21,1	1,7	19,5	Bild 009
5		790,3	17	205	1000			18,1	39,2	17,1	40,2	77,7	38,5	2,0	21,1	Bild 011
6		861,9	17	205	120			22,5	46,3	23,1	46,9	77,7	31,4	2,0	21,8	Bild 013
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bmvit 1 von 3 Gerhard Hanappi-Stadion_1

RX Position 2:

Messbericht

Datum	13.Februar 2008	Lfd. Nr.:	Standort 2	Dienststelle:	FÜ-Wien
Messort:	1140 Wien, Linzerstraße 370			Koordinaten:	48N12 04 16E15 55

(das Datum kann automatisch durch Drücken des "Datum" Button befüllt werden)

Messmittel:

X	EMI-Messempfänger	ESCI
X	Richtantenne	HL-015
X	Mikrowellenkabel	10 m

Referenz/Bemerkungen zu den nachstehenden Messungen:

Standort der Funkmikrofone:
Gerhard Hanappi Stadion 48N11 51,6 16E15 57,7

Messantennenhöhe = 5 m
Polarisation = vertikal

			Messwerte										Dämpfung		Faktoren		
	Uhrzeit hh:mm	Messfrequenz in MHz	Senderstandort (ME=Messentfernung)		Mess-bandbreite in kHz	Messwert in dBµV an 50 Ohm (mit Umrechnung auf Feldstärke)							max. zu erwartende Feldstärke bei Freiraumausbreitung in dBµV/m	Zusatzdämpfung Übertragungsstrecke (bei Avg Messwert) in dB	Kabel Dämpfung in dB	Antennen-Faktor in dB	Bild-Dokumentation
						Peak		Avg		RMS							
			EIRP des Senders in dBm	ME in m		U dBµV	E dBµV/m	U dBµV	E dBµV/m	U dBµV	E dBµV/m						
1		1.495,0	17	367	1000			17,1	46,7	18,0	47,6	72,6	25,9	2,8	26,8	Bild 017
2		1.500,0	20	367	1000			19,2	48,8	20,0	49,6	75,6	26,8	2,8	26,8	Bild 020
3		1.515,0	17	367	1000			17,5	47,1	18,5	48,1	72,6	25,5	2,8	26,8	Bild 021
4		650,1	17	367	1000			25,8	47,0	26,0	47,2	72,6	25,6	1,7	19,5	Bild 024
5		790,3	17	367	1000			16,4	39,5	17,4	40,5	72,6	33,1	2,0	21,1	Bild 026
6		861,9	17	367	1000			17,8	41,6	18,8	42,6	72,6	31,0	2,0	21,8	Bild 028
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bmvit 2 von 3 Gerhard Hanappi-Stadion_2

RX Position 3:

Messbericht

Datum	13.Februar 2008	Lfd. Nr.:	Standort 3	Dienststelle:	FÜ-Wien
Messort:	1140 Wien, Keißlergasse			Koordinaten:	48N11 51 16E15 48

(das Datum kann automatisch durch Drücken des "Datum" Button befüllt werden)

Messmittel:

X	EMI-Messempfänger	ESCI
X	Richtantenne	HL-015
X	Mikrowellenkabel	10 m

Referenz/Bemerkungen zu den nachstehenden Messungen:

Standort der Funkmikrofone:
Gerhard Hanappi Stadion 48N11 51,6 16E15 57,7

Messantennenhöhe = 8 m
Polarisation = vertikal

			Messwerte										Dämpfung		Faktoren		
	Uhrzeit hh:mm	Messfrequenz in MHz	Senderstandort (ME =Messentfernung) EIRP des Senders in dBm	ME in m	Mess-bandbreite in kHz	Messwert in dBµV an 50 Ohm (mit Umrechnung auf Feldstärke) Peak U dBµV	Peak E dBµV/m	Avg U dBµV	Avg E dBµV/m	RMS U dBµV	RMS E dBµV/m	max. zu erwartende Feldstärke bei Freiraumausbreitung in dBµV/m	Zusatzdämpfung Übertragungsstrecke (bei Avg Messwert) in dB	Kabel Dämpfung in dB	Antennen-Faktor in dB	Bild-Dokumentation
1		1.495,0	17	205	1000			19,3	48,9	20,1	49,7	77,7	28,8	2,8	26,8	Bild 029
2		1.500,0	20	205	1000			26,1	55,7	26,3	55,9	80,7	25,0	2,8	26,8	Bild 032
3		1.515,0	17	205	1000			18,2	47,8	19,1	48,7	77,7	29,9	2,8	26,8	Bild 033
4		650,1	17	205	120			27,5	48,7	27,6	48,8	77,7	29,0	1,7	19,5	Bild 036
5		790,3	17	205	120			7,7	30,8	8,8	31,9	77,7	46,9	2,0	21,1	Bild 037
6		861,9	17	205	120			21,4	45,2	21,5	45,3	77,7	32,5	2,0	21,8	Bild 039
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Appendix 3: 'Gerhard Hanappi Stadion' Measurement reports provided by BMViT

RX Position 1:

Messbericht

Datum	14.Februar 2008	Lfd. Nr.:	Standort 1	Dienststelle:	FÜ-Wien
Messort:	1090 Wien, Fuchsthallergasse			Koordinaten:	48N13 30 16E21 04

(das Datum kann automatisch durch Drücken des "Datum"-Button befüllt werden)

Messmittel:

X	EMI-Messempfänger	ESCI
X	Richtantenne	HL-015
X	Mikrowellenkabel	10 m

Referenz/Bemerkungen zu den nachstehenden Messungen:

Standort der Funkmikrofone:
Volksoper 48N13 29 16E21 01

Messantennenhöhe = 2,5 m (auf Wunsch)
Polarisation = vertikal

			Messwerte										Dämpfung		Faktoren		
	Uhrzeit hh:mm	Messfrequenz in MHz	Senderstandort (ME=Messentfernung) EIRP des Senders in dBm	ME in m	Messbandbreite in kHz	Messwert in dBµV an 50 Ohm (mit Umrechnung auf Feldstärke) Peak U dBµV	Peak E dBµV/m	Avg U dBµV	Avg E dBµV/m	RMS U dBµV	RMS E dBµV/m	max. zu erwartende Feldstärke bei Freiraumausbreitung in dBµV/m	Zusatzdämpfung Übertragungsstrecke (bei Avg Messwert) in dB	Kabel-Dämpfung in dB	Antennen-Faktor in dB	Bild-Dokumentation
1		1.495,0	17	82	1000	37,8	67,4	33,7	63,3	33,8	63,4	85,6	22,3	2,8	26,8	Bild 001
2		1.500,0	20	82	1000	36,4	66,0	32,6	62,2	32,6	62,2	88,6	26,4	2,8	26,8	Bild 002
3		1.515,0	17	82	1000	31,5	61,1	24,0	53,6	24,1	53,7	85,6	32,0	2,8	26,8	Bild 003
4		650,1	17	82	120	44,4	65,6	43,8	65,0	43,8	65,0	85,6	20,6	1,7	19,5	Bild 004
5		790,3	17	82	120	41,7	64,8	40,9	64,0	40,9	64,0	85,6	21,6	2,0	21,1	Bild 005
6		861,9	17	82	120	38,7	62,5	37,8	61,6	37,8	61,6	85,6	24,0	2,0	21,8	Bild 006
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RX Position 2:

Messbericht

Datum	14.Februar 2008	Lfd. Nr.:	Standort 2	Dienststelle:	FÜ-Wien
Messort:	1090 Wien, Fuchsthallergasse/Währinger Gürtel			Koordinaten:	48N13 30 16E21 00

(das Datum kann automatisch durch Drücken des "Datum"-Button befüllt werden)

Messmittel:

X	EMI-Messempfänger	ESCI
X	Richtantenne	HL-015
X	Mikrowellenkabel	10 m

Referenz/Bemerkungen zu den nachstehenden Messungen:

Standort der Funkmikrofone:
Volksoper 48N13 29 16E21 01

Messantennenhöhe = 2,5 m (auf Wunsch)
Polarisation = vertikal

			Messwerte										Dämpfung		Faktoren		
	Uhrzeit hh:mm	Messfrequenz in MHz	Senderstandort (ME=Messentfernung) EIRP des Senders in dBm	ME in m	Messbandbreite in kHz	Messwert in dBµV an 50 Ohm (mit Umrechnung auf Feldstärke) Peak U dBµV	Peak E dBµV/m	Avg U dBµV	Avg E dBµV/m	RMS U dBµV	RMS E dBµV/m	max. zu erwartende Feldstärke bei Freiraumausbreitung in dBµV/m	Zusatzdämpfung Übertragungsstrecke (bei Avg Messwert) in dB	Kabel-Dämpfung in dB	Antennen-Faktor in dB	Bild-Dokumentation
1		1.495,0	17	45	1000	44,8	74,4	43,1	72,7	43,1	72,7	90,9	18,2	2,8	26,8	Bild 007
2		1.500,0	20	45	1000	51,6	81,2	50,9	80,5	50,9	80,5	93,9	13,4	2,8	26,8	Bild 008
3		1.515,0	17	45	1000	42,3	71,9	40,7	70,3	40,7	70,3	90,9	20,6	2,8	26,8	Bild 009
4		650,1	17	45	120	54,8	76,0	54,6	75,8	54,6	75,8	90,9	15,1	1,7	19,5	Bild 010
5		790,3	17	45	120	44,0	67,1	43,5	66,6	43,5	66,6	90,9	24,3	2,0	21,1	Bild 011
6		861,9	17	45	120	45,4	69,2	45,0	68,8	44,9	68,7	90,9	22,1	2,0	21,8	Bild 012
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RX Position 3:

Messbericht

Datum	14.Februar 2008	Lfd. Nr.:	Standort 3	Dienststelle:	FÜ-Wien
Messort:	1090 Wien, Lustkandlgasse			Koordinaten:	48N13 30 16E21 03

(das Datum kann automatisch durch Drücken des "Datum" Button befüllt werden)

Messmittel:

X	EMI-Messempfänger	ESCI
X	Richtantenne	HL-015
X	Mikrowellenkabel	10 m

Referenz/Bemerkungen zu den nachstehenden Messungen:

Standort der Funkmikrofone:
Volksoper 48N13 29 16E21 01

Messantennenhöhe = 8 m
Polarisation = vertikal

			Messwerte										Dämpfung		Faktoren		
	Uhrzeit hh:mm	Messfrequenz in MHz	Senderstandort (ME=Messentfernung) EIRP des Senders in dBm	ME in m	Mess-bandbreite in kHz	Messwert in dBµV an 50 Ohm (mit Umrechnung auf Feldstärke) Peak U dBµV	Peak E dBµV/m	Avg U dBµV	Avg E dBµV/m	RMS U dBµV	RMS E dBµV/m	max. zu erwartende Feldstärke bei Freiraumausbreitung in dBµV/m	Zusatzdämpfung Übertragungsstrecke (bei Avg Messwert) in dB	Kabel Dämpfung in dB	Antennen-Faktor in dB	Bild-Dokumentation
1		1.495,0	17	60	1000	39,0	68,6	25,6	55,2	25,9	55,5	88,4	33,2	2,8	26,8	Bild 013
2		1.500,0	20	60	1000	45,0	74,6	35,2	64,8	35,3	64,9	91,4	26,6	2,8	26,8	Bild 014
3		1.515,0	17	60	1000	45,4	75,0	24,5	54,1	24,8	54,4	88,4	34,3	2,8	26,8	Bild 015
4		650,1	17	60	120	48,3	69,5	32,1	53,3	32,1	53,3	88,4	35,1	1,7	19,5	Bild 016
5		790,3	17	60	120	31,5	54,6	29,0	52,1	29,1	52,2	88,4	36,3	2,0	21,1	Bild 017
6		861,9	17	60	120	30,6	54,4	25,2	49,0	25,4	49,2	88,4	39,4	2,0	21,8	Bild 018
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11																
12																

bmvit — 3 von 3 — Volksoper_3

ANNEX 4: REFERENCES

[1] SRDoc TR 102 546: Technical characteristics for Professional Wireless Microphone Systems (PWMS)

[2] ERC/REC 70-03: Relating to the use of Short Range Devices (SRD)

[3] ETSI EN 300 422: Wireless microphones in the 25 MHz to 3 GHz frequency range

[4] ERC Report 25: The European table of frequency allocations and utilisations covering the frequency range 9 kHz to 275 GHz

[5] ECC Report 003: Fixed Service in Europe Current and Future Use and Future Trends Post-2002

[6] Recommendation T/R 13-01: Channel arrangements for fixed services in the range 1-3 GHz

[7] ECC/DEC/(04)09: on the designation of the bands 1518-1525 MHz and 1670-1675 MHz for the Mobile-Satellite Service

[8] ECC/DEC/(07)04 : Free circulation and use of mobile satellite terminals operating in the Mobile-Satellite Service allocations in the frequency range 1-3 GHz

[9] ECC/DEC/(07)05 : Reserving the National Numbering Range beginning with '116' for Harmonised Numbers for Harmonised Services of Social Value. Amended 26 February 2008

[10] MA02revCO07: The Maastricht, 2002, Special Arrangment, as revised in Constanța, 2007

[11] ITU-R Recommendation F.1334: Protection criteria for systems in the fixed service sharing the same frequency bands in the 1 to 3 GHz range with the land mobile service

[12] EN 300 630: Low capacity point to point digital radio relay systems in the 1,4 GHz band

[13] EN 300 631 : Fixed Radio Systems; Point-to-Point Antennas; Antennas for Point-to-Point fixed radio systems in the 1 GHz to 3 GHz band

[14] ITU-R Recommendation F.1245: Mathematical model of average radiation patterns for line-of-sight point-to-point radio-relay system antennas for use in certain coordination studies and interference assessment in the frequency range from 1 GHz to about 70 GHz

[15] ERC Report 10: Compatibility between DECT and radio relay systems in the 2 GHz band.

[16] ECC/DEC/(03)02: Designation of the frequency band 1479.5-1492 MHz for use by Satellite Digital Audio Broadcasting systems

[17] ETSI TR 102 525 (2006-09), technical report on SDR technology

[18] ETSI TS 102 550 (2006-11), Outer Physical Layer

[19] ETSI TS 102 551-1 (2006-12), SDR Inner Physical Layer Single Carrier

[20] ETSI TS 102 551-2 (2006-12), SDR Inner Physical Layer Multiple Carrier

[21] ITU-R Recommendation M.1459: Protection criteria for telemetry systems in the aeronautical mobile service and mitigation techniques to facilitate sharing with geostationary broadcasting-satellite and mobile-satellite services in the frequency bands 1 452-1 525 MHz and 2 310-2 360 MHz

[22] ITU-R Recommendation RS.1166-3: Performance and interference criteria for active spaceborne sensors

[23] ITU-R Recommendation M.1388: Threshold levels to determine the need to coordinate between space stations in the broadcasting-satellite service (sound) and particular systems in the land mobile service in the band 1 452-1 492 MHz

[24] ITU-R Recommendation M.1731: Protection criteria for Cospas-Sarsat local user terminals in the band 1 544-1 545 MHz

RECOMMENDATION ITU-R M.1459*

PROTECTION CRITERIA FOR TELEMETRY SYSTEMS IN THE AERONAUTICAL MOBILE SERVICE AND MITIGATION TECHNIQUES TO FACILITATE SHARING WITH GEOSTATIONARY BROADCASTING-SATELLITE AND MOBILE-SATELLITE SERVICES IN THE FREQUENCY BANDS 1 452-1 525 MHz AND 2 310-2 360 MHz

(Question ITU-R 62/8)

(2000)

The ITU Radiocommunication Assembly,

considering

a) that in Region 2, frequency allocations to the aeronautical mobile service for telemetry have a primary status in the band 1 435-1 525 MHz and have priority over other mobile services under RR No. S5.343;

b) that WARC-92 adopted an additional allocation in the band 1 429-1 535 MHz, on a primary basis to the aeronautical mobile service for Belarus, the Russian Federation and Ukraine to be used exclusively for aeronautical telemetry subject to RR No. S5.342;

c) that in accordance with the decision by WRC-95, in the United States of America, telemetry stations in the aeronautical mobile service have a primary status in the 2 300-2 390 MHz band and have priority over other mobile services under RR No. S5.394;

d) that in Canada, telemetry stations in the aeronautical mobile service have a primary status in the 2 300-2 483.5 MHz band and have priority over other mobile services under RR No. S5.394;

e) that in France, frequency assignments to telemetry stations in the aeronautical mobile service have a primary status in the 2 310-2 360 MHz band and have priority over other mobile services under RR No. S5.395;

f) that in Europe future airborne telemetry equipment should tune primarily to the frequency range 2 300-2 400 MHz;

g) that the band 1 492-1 525 MHz has been allocated to the MSS (space-to-Earth) in Region 2 taking account of the provisions of RR Nos. S5.348 and S5.348A;

h) that WARC-92 allocated the band 1 452-1 492 MHz on a primary basis to the BSS (digital sound broadcasting (DSB)) (see Note 1) and the broadcasting service (DSB) subject to the provisions of RR Nos. S5.345 and S5.347;

j) that at WARC-92, an additional allocation in the United States of America, India and Mexico of the 2 310-2 360 MHz band to BSS (DSB) and the broadcasting service (DSB) was made on a primary basis under RR No. S5.393;

k) that in the band 1 452-1 525 MHz, WARC-92 adopted an alternative allocation on a primary basis for the fixed and mobile services in the United States of America in accordance with RR No. S5.344;

l) that in Japan in the band 1 492-1 525 MHz, a coordination threshold of -150 dB(W/m^2) in any 4 kHz band for all angles of arrival was adopted at WRC-95 for the protection of specialized land mobile services in accordance with RR No. S5.348A;

m) that coordination is required under RR No. S9.11A and Resolution 528 (WARC-92);

n) that Resolutions 528 (WARC-92) and 213 (Rev.WRC-95) invited the ITU-R to conduct the necessary studies prior to the next competent WRC;

o) that additional studies have been introduced in the ITU-R for determining the probability of interference to telemetry stations in the aeronautical mobile service which could lead to less stringent protection values, and that these studies are expected to continue;

* This Recommendation should be brought to the attention of Radiocommunication Study Group 6.

p) that telemetry stations in the aeronautical mobile service have a wide range of characteristics and some may have less stringent protection criteria values than those contained in the *recommends*,

recommends

1 that the values needed for protection of the aeronautical mobile service for telemetry systems in the 1 452-1 525 MHz band shared with geostationary satellites in the BSS (DSB) or the MSS, should be determined by the following (see Note 4):

– for geostationary satellites visible to any aeronautical telemetry receiving station, the protection value corresponds to a pfd at the telemetry receiving station in any 4 kHz band for all methods of modulation:

-181.0	$\text{dB(W/m}^2)$	for	$0° \leq \alpha \leq 4°$
$-193.0 + 20 \log \alpha$	$\text{dB(W/m}^2)$	for	$4° < \alpha \leq 20°$
$-213.3 + 35.6 \log \alpha$	$\text{dB(W/m}^2)$	for	$20° < \alpha \leq 60°$
-150.0	$\text{dB(W/m}^2)$	for	$60° < \alpha \leq 90°$

where α is the angle of arrival (degrees above the horizontal plane);

2 that the values needed for protection of the aeronautical mobile service for telemetry systems in the 2 310-2 360 MHz band shared with the BSS (DSB) should be determined by the following (see Note 4):

– for geostationary satellites visible to any aeronautical telemetry receiving station, the protection value corresponds to a pfd at the telemetry receiving station in any 4 kHz band for all methods of modulation:

-180.0	$\text{dB(W/m}^2)$	for	$0° \leq \alpha \leq 2°$
$-187.1 + 23.66 \log \alpha$	$\text{dB(W/m}^2)$	for	$2° < \alpha \leq 11{,}5°$
-162	$\text{dB(W/m}^2)$	for	$11.5° < \alpha \leq 90°$

where α is the angle of arrival (degrees above the horizontal plane);

3 that the calculation methods and mitigation techniques given in Annexes 1 and 2 may be used, as applicable, for determining the probability of interference to telemetry systems in the aeronautical mobile service.

NOTE 1 – DSB refers to digital audio broadcasting as per RR Nos. S5.345 and S5.393.

NOTE 2 – The example calculation used to derive the protection values as set out in Annex 1 represent a worst-case scenario. Mitigation techniques given in Annex 2 may enhance sharing.

NOTE 3 – As safety of life aspects are to be considered with mobile aeronautical telemetry systems and efficient use of the spectrum allocated by WARC-92 to the BSS (sound) appears not to be possible, attention is drawn to studies being conducted under Question ITU-R 204/10 (see Recommendation ITU-R BO.1383).

NOTE 4 – Administrations are encouraged to submit information to ITU-R concerning performance and availability targets for the mobile aeronautical telemetry service with a view to developing an appropriate ITU-R Recommendation.

ANNEX 1

Calculation of pfd interference levels to aeronautical mobile telemetry systems from geostationary satellite emissions

1 Introduction

The analyses and results given in the following sections of this Annex are for the purpose of calculating interference to aeronautical mobile telemetry systems.

2 Development of values

The following development can be used in general, but the numerical values are for the 1 452-1 525 MHz band.

2.1 Telemetry system characteristics

General system characteristics are given in the CPM Report to WARC-92 and are as follows. Aeronautical telemetry and telecommand operations are used for flight testing of manned and unmanned aerospace vehicles. Vehicles are tested to their design limits, thus making safety of flight dependent on the reliability of information received on a real-time basis. When being tested to design limits, signal strength loss can exceed 30 dB due to nulls in the aircraft antenna pattern caused by aircraft attitude changes.

Required *C/N*:	9-15 dB
Transmitter power:	2-25 W
Modulation type:	PCM/FM
Transmission path length:	up to 320 km
Receiving system noise temperature:	200-500 K
Receiving antenna gain:	20-41 dB

Receive antenna first side-lobe levels for two antennas:

10 m (diameter):	20 dBi (antenna gain)
	2.4° (from centre)
2.44 m (diameter):	7-14 dBi (antenna gain)
	10° (from centre)

A number of antenna diameters are employed between the 20-41 dB limits. Left-hand and right-hand circular, as well as linear polarizations, are used.

Channel assignments are made in 1 MHz increments. Typical emissions are 1, 3 and 5 MHz in bandwidth with wider assignments made for video and other complex measurements.

The maximum air space for a telemetry receiving site is defined as a cylinder with a horizontal radius of 320 km around the site, with the lower bound determined by visibility and the upper bound determined by an altitude of 20 km. The minimum air space for a particular mission is defined as a vertical cylinder with a radius of 20 km within the maximum air space with the same lower and upper bounds as for the maximum air space.

Continuous RF tracking is employed using both monopulse and conical scan techniques.

Two antenna diameters are given a 2.44 m and a 10 m diameter. Figure 1 shows measured gain values for three 2.44 m antennas. Since these antennas track a moving vehicle so that the antenna gain toward a geostationary satellite is variable, there is a side lobe and backlobe gain which is exceeded or not exceeded 50% of the time. The following composite pattern is developed on this basis for antenna gains from 29 dB to 41.2 dB.

$$G(\theta) = 41.2 + 20 \log \left(\frac{\sin 1.952\,\theta}{1.952\,\theta} \right) \quad \text{dBi} \quad \text{for} \quad 0° \leq \theta \leq 0.94° \qquad (1a)$$

$$G(\theta) = 35.1 - 20 \log \theta \quad \text{dBi} \quad \text{for} \quad 0.94° < \theta \leq 3.82° \qquad (1b)$$

$$G(\theta) = 29 + 20 \log \left(\frac{\sin 0.479\,\theta}{0.479\,\theta} \right) \quad \text{dBi} \quad \text{for} \quad 3.82° < \theta \leq 5.61° \qquad (1c)$$

$$G(\theta) = 27.27 - 18.75 \log \theta \quad \text{dBi} \quad \text{for} \quad 5.61° < \theta \leq 12.16° \qquad (1d)$$

$$G(\theta) = 34.05 - 25 \log \theta \quad \text{dBi} \quad \text{for} \quad 12.16° < \theta \leq 48° \qquad (1e)$$

$$G(\theta) = -8 \quad \text{dBi} \quad \text{for} \quad 48° < \theta \leq 180° \qquad (1f)$$

The values of 1.952 and 0.479 associated with angle θ are in radians.

The telemetry transmitting antennas are mounted on airborne vehicles and, ideally, would be isotropic radiators to cover all possible radiation angles toward the telemetry receiving station. However, in practice, multiple reflections and blockage from the airborne vehicles cause large variations in the gain pattern. Multiple reflections generally result in a Raleigh fading distribution, and measured gain functions have shown that this is approximately the case as shown in Fig. 2. Using Fig. 2 for a near-worst case, including propagation effects, the probability (portion of time), P_1, that a given gain, G_1, is not exceeded can be expressed as:

$$P_1 \, (G \leq G_1) = (1 - e^{-3.46 \, G_1})^{1.25} \text{ (numerical)} \tag{2}$$

Distributions corresponding to an exponent of $(-5G_1)$ are observed.

The received C/N and carrier power, C, at output of the telemetry receiving antenna are proportional to this function.

FIGURE 1

Measured data on 2.44 m diameter antennas

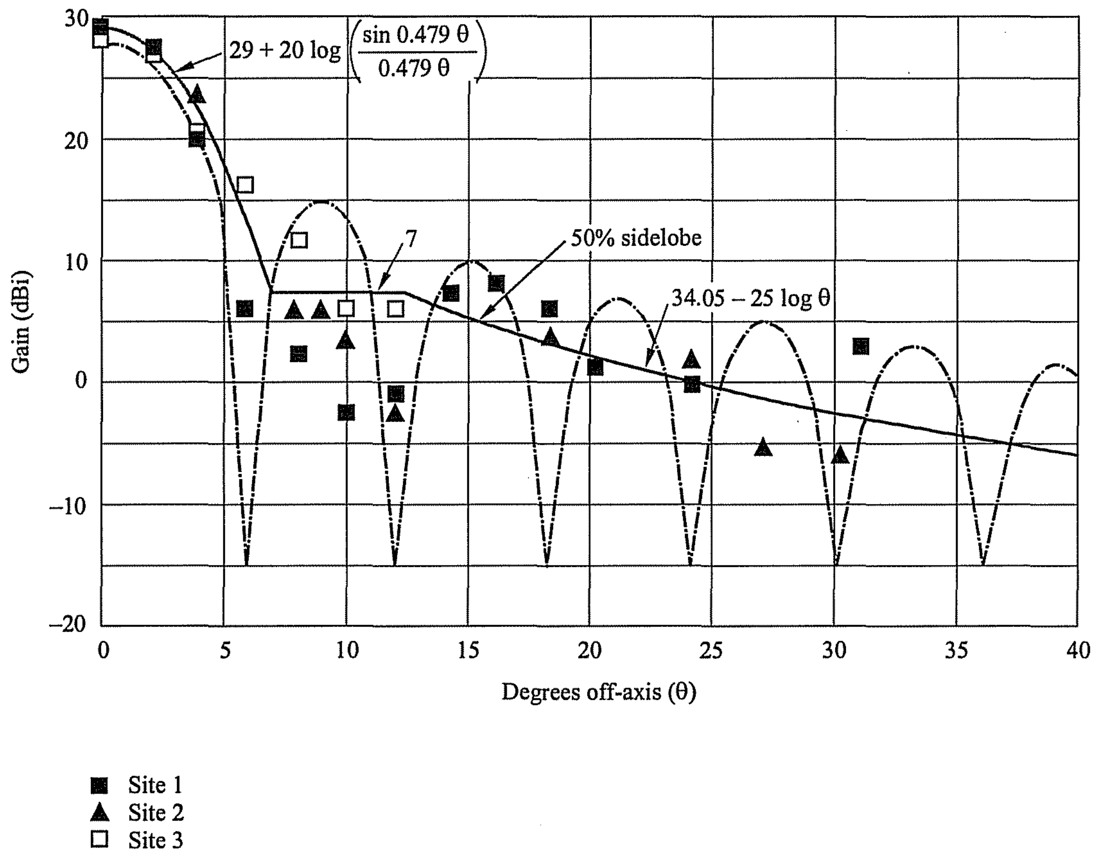

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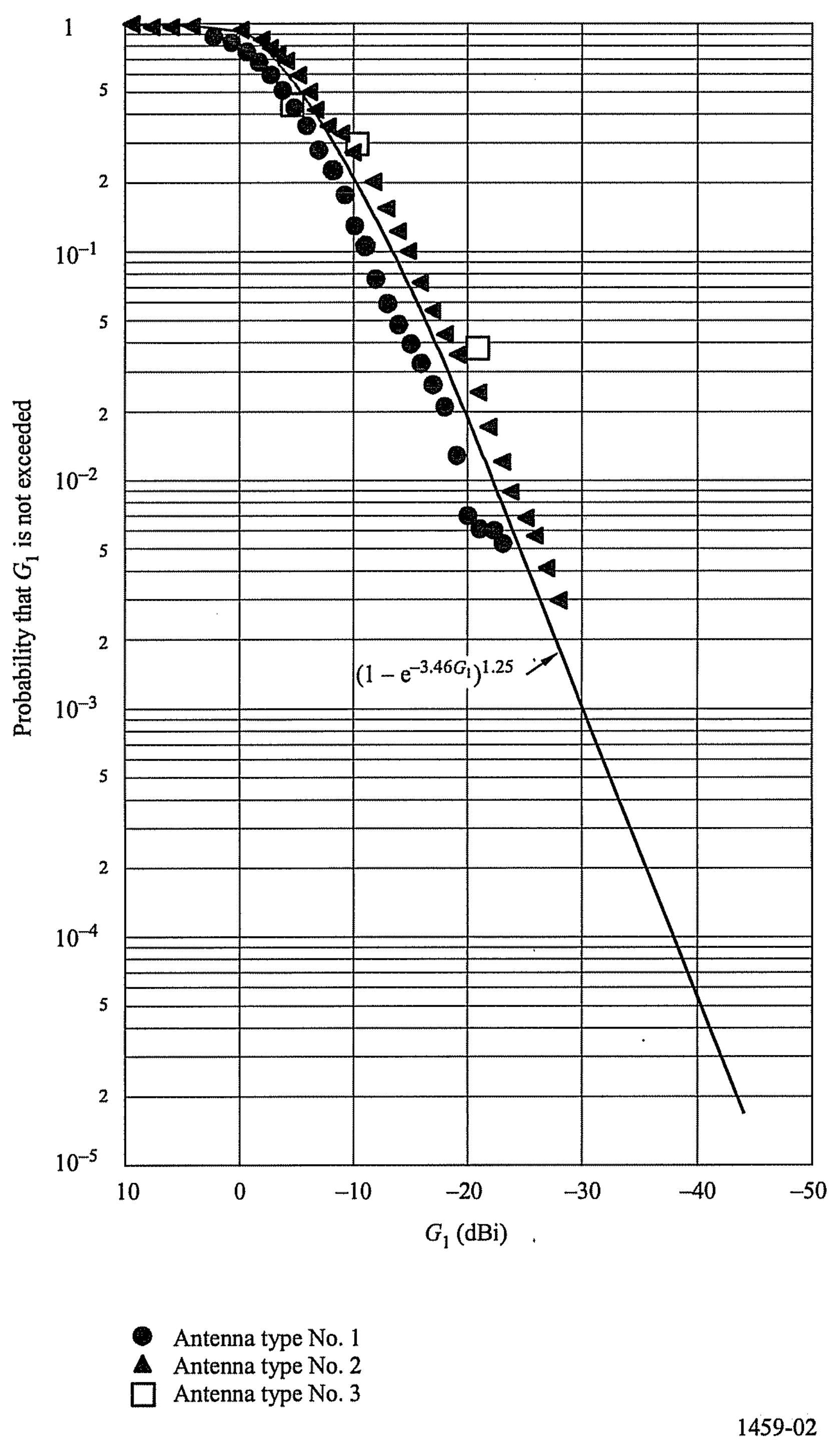
FIGURE 2

Airborne telemetry transmitting antenna gains, G_1



2.2 Interference from geostationary satellites

2.2.1 Time-gain function of interference

If it is assumed that the telemetry antenna may be pointed at any point on its hemisphere of visibility, the cumulative probability, P_2, that a satellite at geostationary altitude is within a radius of θ, as viewed from the telemetry receiving station, is:

$$P_2 = (1 - \cos \theta) \qquad \text{for} \qquad 0 \leq \theta \leq \pi/2 \tag{3}$$

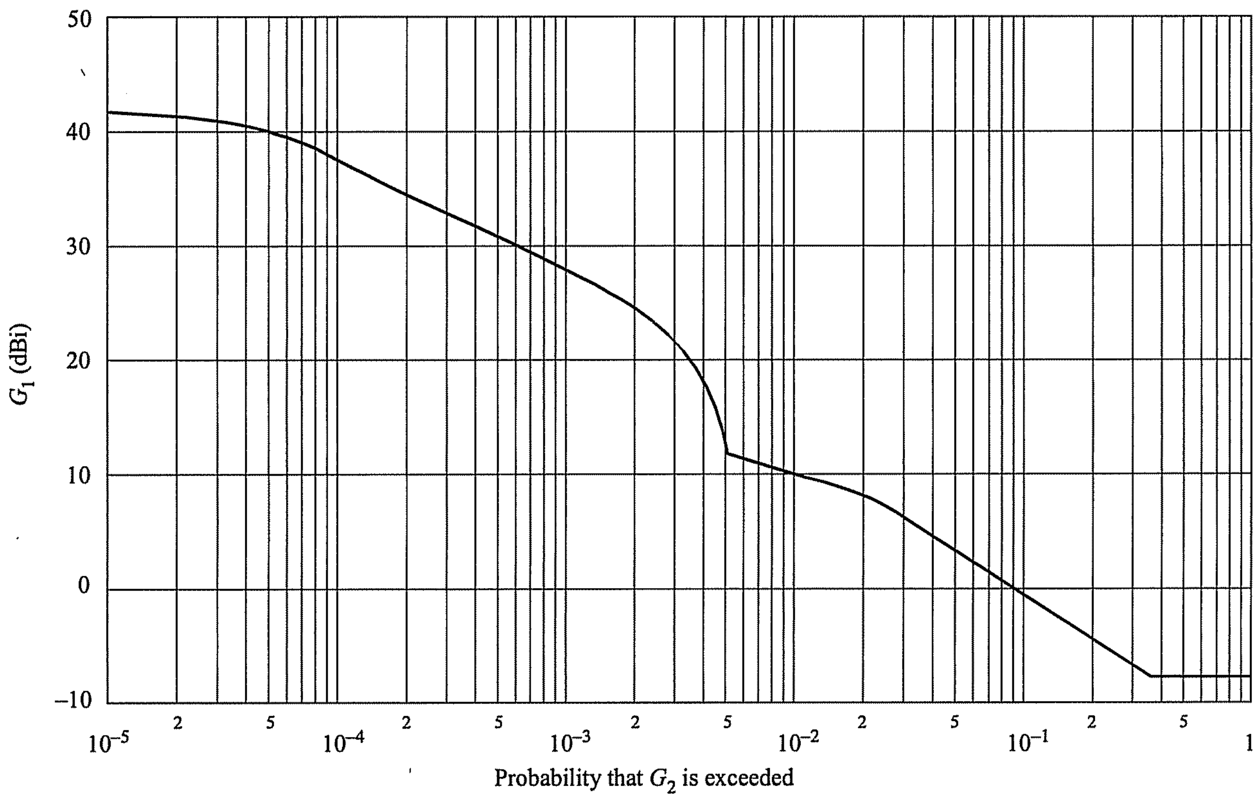
The θ in equation (1) is the same as in equation (3). Thus, by combining equations (1) with (3), functions can be developed which relate the probability (portion of time) that the telemetry receiving antenna gain, G, toward the satellite is equal to or greater than a given value, G_2, as shown in Fig. 3.

The received I/N and the interference power, I, are proportional to the functions shown in Fig. 3.

In the case of geostationary satellite, the angle-of-arrival of interference at a telemetry receiving station is fixed. The only randomness involved is the telemetry receiving antenna pointing variations. Testing of airborne vehicles is often restricted to areas over water or uninhabited land in order to preclude danger to life or property in case of catastrophic failure of the vehicle being tested, thereby limiting the azimuth angles for these tests. There are also minimum limits on the azimuth and elevation pointing angle variations of the telemetry receiving antenna that are defined by the minimum air space in § 2.1.

FIGURE 3

Telemetry receiving antenna gain probability, G_2



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2.2.2 *C/I* analysis

Since equation (2) is proportional to C and the functions in Fig. 3 are proportional to I, the probability of C/I can be determined and is proportional to:

$$P((C/I) \geq (C/I)_c) \propto \left[(P_1(G' \leq G_1))/(P_2(G'' \leq G_2))\right] \tag{4}$$

where $(C/I)_c$ is a chosen value.

The square brackets indicate the joint, cumulative probability function. The C and I functions are independent since they result from independent sources. The indicated integrations were performed for various limited ranges of P_2 which, in turn, corresponds to limited steradian areas, S, when the satellite is within the minimum airspace defined in § 2.1. These integrations may be expressed as:

$$P_3(\Delta G \geq G_2/G_1) = \left[(P_2(G'' \geq G_2))/(P_1(G' \leq G_1))\right] \tag{5}$$

The (C/I) in equation (4) is normally expressed in relation to (C/N), and since loss of availability is the prime concern, it is expressed in relation to the threshold $(C/N)_T$ as follows:

$$(C/I) \geq (C/N)_T (P_4/P_3) \tag{6}$$

where

P_4: probability associated with $(C/N)_T$ and is set equal to $P(\Delta G)$

P_3: probability associated with (C/I).

The ratio (P_4/P_3) is analogous and numerically equal to (I/N) criteria. The allowable non-availability, P, is based on $C/(N+I)$ so that $P(\Delta G) = P - P_3$ which results in:

$$P(\Delta G) = P/(I/N + 1) \tag{7}$$

It is now necessary to relate ΔG to pfd. First, a pfd is determined when the telemetry antenna is directed toward the satellite:

$$pfd \leq \frac{k\,T\,B(I/N)}{(\lambda^2/4\pi)\,G_0} \qquad \text{W/(m}^2 \cdot B) \tag{8}$$

where:

k: Boltzmann's constant

T: noise temperature (K)

B: bandwidth (Hz)

$G_0 = 13\,183$ (41.2 dB).

This pfd is associated with a $(\Delta G)_m$ at a $P(\Delta G)$. At G_0, only C is variable and thus, C/I is given by equation (2). The $(\Delta G)_m$ function is closely approximated by:

$$(\Delta G)_m = 45\,000/P(\Delta G)^{1.25} \tag{9}$$

The pfd from equation (8) can be increased by $(\Delta G)_m/(\Delta G)$. Thus:

$$pfd \leq \frac{k\,T\,B(I/N)}{G_0\,(\lambda^2/4\pi)} \times \frac{(\Delta G)_m}{(\Delta G)} \qquad P(\Delta G)_m = P(\Delta G) \qquad \text{W/(m}^2 \cdot B) \tag{10}$$

2.2.3 Impact on telemetry link design

Analyses show that the value of P, the telemetry link non-availability, does not significantly affect the pfd values. The pfd values are primarily determined by the value of (I/N). The impact on the telemetry link measured in terms of the decrease in usable range, R, for a given P, as a function of (I/N) can be determined from equation (7), since $R^2 \propto 1/(N + \mathrm{I})$ for a fixed transmitter power. The decreased usable range as a function of (I/N) is shown in Fig. 4. The impact on telemetry link design becomes severe for (I/N) values greater than one (0 dB) because the link must be designed to overcome interference rather than internal noise. The maximum practical value is considered to be approximately 0.5 (–3 dB) with smaller values desired.

2.2.4 Interference allowances

Based on the factors given in § 2.2.3, the following aggregate allowances appear appropriate for this case. The total noise is the sum of internal noise, N_I, plus interference from satellites, I_S, plus interference from terrestrial sources, I_T. The aggregate permissible interference from satellites and terrestrial sources are:

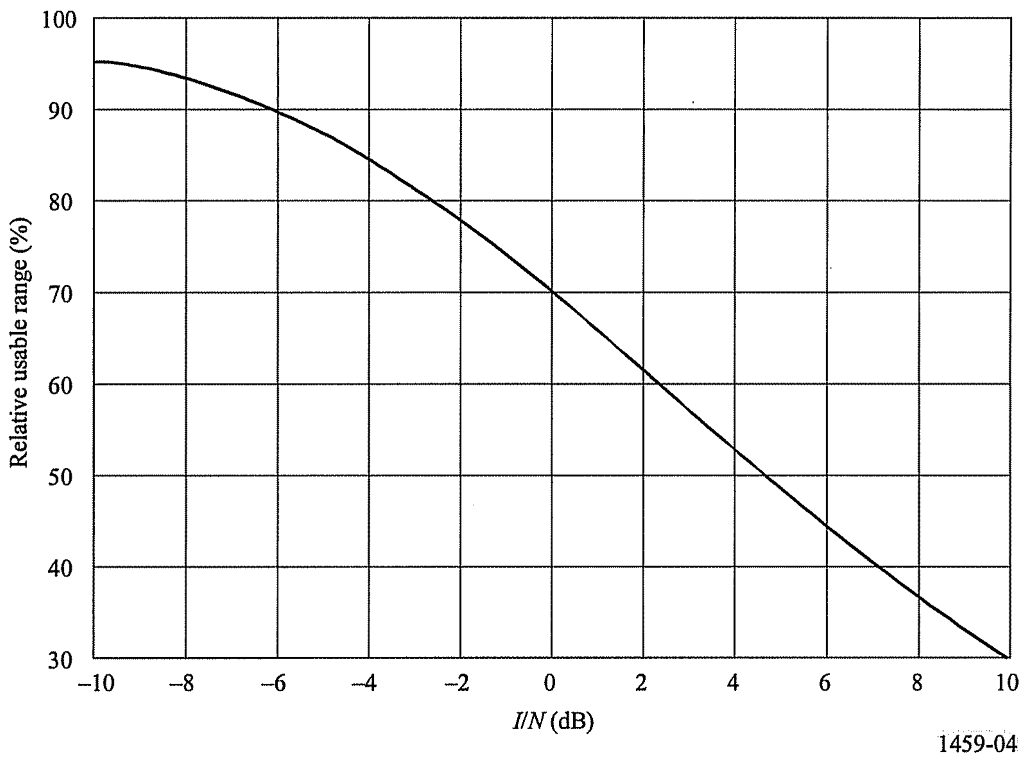
$$I_S = 0.25\,(N_I + I_S + I_T) \tag{11}$$

$$I_T = 0.10\,(N_I + I_S + I_T) \tag{12}$$

From this, the aggregate allowable I/N from satellites is 0.3846 or –4.15 dB, and from terrestrial sources is 0.1538 or –8.13 dB. Since pfd is not particularly sensitive to P, a mid-range value of P of 0.005 is selected for numerical evaluation which results in a $P(\Delta G)$ of 0.003611 from equation (7).

FIGURE 4

Decrease in usable range versus *I/N*



2.2.5 Minimum *S* versus angle of arrival, α

The minimum value of *S* can be determined from the minimum radius of a circle in which aircraft testing is normally accomplished (see Fig. 5). *S* as a function of α is determined as follows. The elevation angle of arrival is:

$$\alpha = \tan^{-1}\left(\frac{h}{d} - \frac{d}{2r}\right) \qquad \text{rad} \tag{13}$$

The incremental angle of arrival, Δα, along the telemetry antenna pointing azimuth is:

$$\Delta\alpha = \tan^{-1}\left(\frac{h}{d-a} - \frac{d-a}{2r}\right) - \tan^{-1}\left(\frac{h}{d+a} - \frac{d+a}{2r}\right) \qquad \text{for } d \geq a \qquad \text{rad} \tag{14a}$$

$$\Delta\alpha = \tan^{-1}\left(\frac{d+a}{h}\right) - \tan^{-1}\left(\frac{d-a}{h}\right) \qquad \text{for } d < a \qquad \text{rad} \tag{14b}$$

The angle tangent to the azimuth, β, is:

$$\beta = 2\tan^{-1}\left(\frac{a\cos\alpha}{d}\right) \qquad \text{rad} \tag{15}$$

From which *S* is:

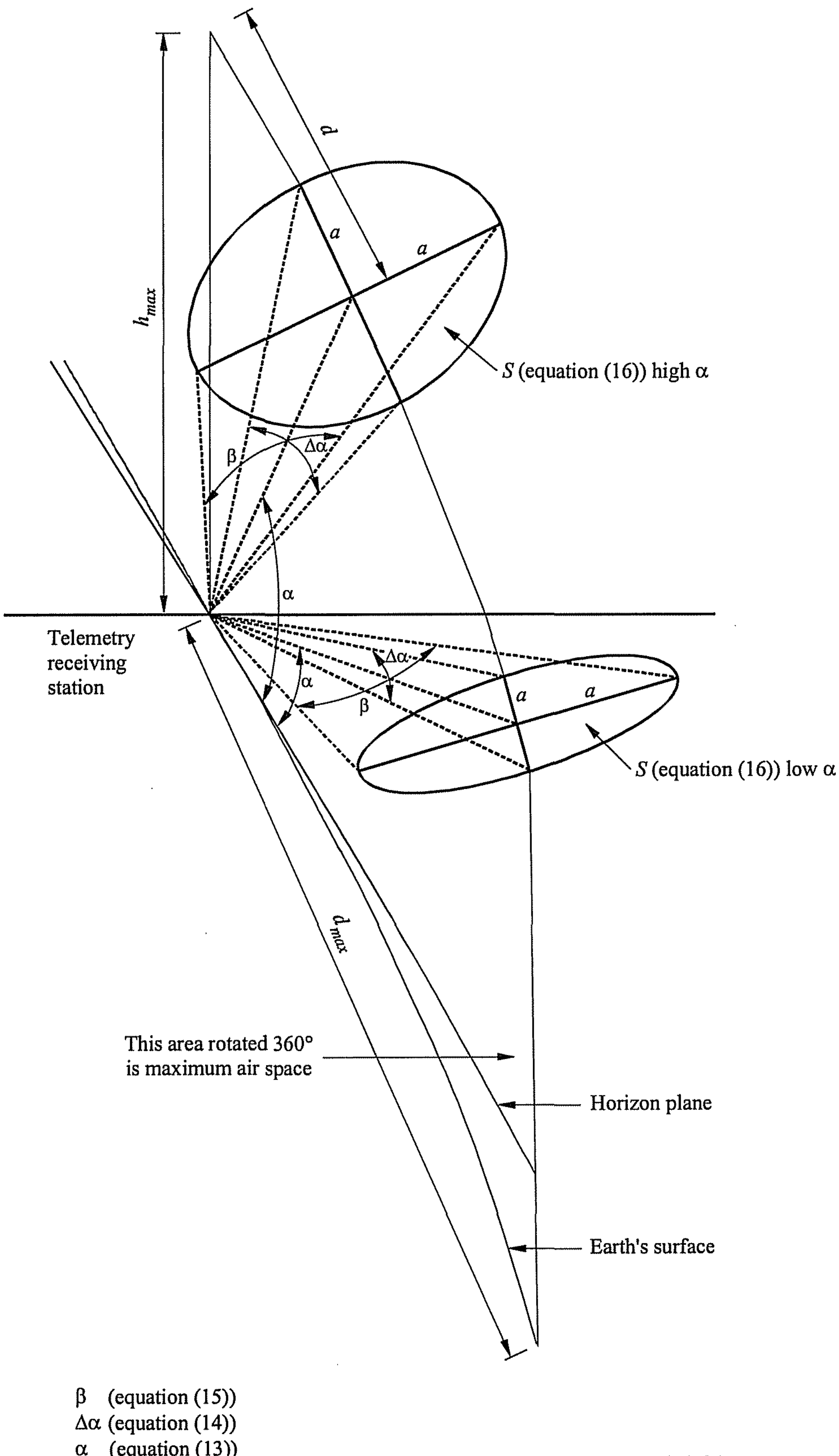
$$S = \pi/4\ (\beta)\ (\Delta\alpha) \qquad \text{steradians} \tag{16}$$

where:

- h: aircraft altitude = 20 km
- d: surface distance to aircraft = 320 km (maximum)
- r: radius of the Earth = 6 378 km
- a: minimum radius of flight patterns = 20 km.

FIGURE 5

Geometry for *S* computations for geostationary satellites



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2.2.6 pfd versus angle of arrival

– pfd escalation due to S

  The permissible pfd increases with S which increases with angle of arrival, α. The pfd as a function of S can be calculated using equation (16), in conjunction with the ΔG versus S functions developed in § 2.2.5, for a $P(\Delta G) = 0.003611$ which, in turn, is used in equation (10). The minimum S is 0.001262 steradians.

– pfd escalation due to excess margin

  There will be some distance, d_0, between the telemetry receiving station and the airborne vehicle at which the desired availability is generally exceeded. Thus, excess margin is available which could be used to increase the allowable pfd. The value of d_0 can be determined by:

$$d_0 = \left\{ \frac{P\, G_a\, G_0}{1758\, k\, T\, B\, M\, f^2 (C/N)_T} \right\}^{0.5} \qquad \text{km} \qquad (17)$$

where:

P: aircraft power (W) = 4

G_a: aircraft median antenna gain = 0.2

G_0: telemetry receiving antenna gain = 800

M: availability margin required = 300

f: frequency (MHz) = 1 500

k: Boltzmann's constant

T: noise temperature (K) = 250

B: bandwidth (Hz) = 3×10^6

$(C/N)_T$: threshold value = 32.

The nominal values for each parameter as listed above are considered to be the most appropriate for determining d_0. The solution of equation (17) with these values result in a d_0 of 40 km.

The angle of arrival, α, is determined by the distance, d and the aircraft height, h and is:

$$\alpha = \arc \sin (h/d) \qquad (18)$$

From equation (18), α as a function of d, for values of d between d_0 and h can be determined. The excess margin, M_e, which can be used to increase the pfd is:

$$M_e = (d_0/d)^2 \qquad (19)$$

The maximum value of h is assumed to be 20 km. Using these values M_e as a function of α is computed. A nearly exact formulation of this function can be expressed as a pfd escalation factor, pfd_e, as follows:

$$pfd_e = 1 \qquad \text{for} \quad 0° \le \alpha \le 30° \qquad (20a)$$

$$pfd_e = 1 + 0.066\,(\alpha - 30) \qquad \text{for} \quad 30° < \alpha \le 62.5° \qquad (20b)$$

$$pfd_e = 4 \sin^2 \alpha \qquad \text{for} \quad 62.5° < \alpha \le 90° \qquad (20c)$$

2.2.7 Multiple entries

When the value of S is very small, sidelobe and back lobe interference levels from similar satellites in the GSO will be insignificant as compared to the main lobe level. As S increases, the sidelobe and back lobe contributions become statistically significant and are accounted for on a per-satellite basis in § 2.2.1. Therefore, multiple entries are primarily related to the number of geostationary satellites within the limited steradian coverage of the telemetry antenna, S.

First, it is assumed that an area, S', is circular and that its diameter, δ, is aligned with the GSO, and second, it is assumed that there are N satellites equally spaced by an angle, Δ, each producing equal pfds at the telemetry antenna.

When δ is equal to Δ, two entries are possible but the probability is near 0. When δ is equal to 2Δ, the probability of two entries is near 1, while probability of three entries is near 0, and so forth. Thus, for a probability of about 0.5:

$$\delta = (N - 0.5)\,\Delta \qquad \delta \text{ and } \Delta\text{, degrees} \tag{21}$$

The area S' is:

$$S' = (\pi/4)\,\delta^2 \qquad \text{steradians} \qquad \delta\text{, rad} \tag{22}$$

From this model, N is closely approximated by:

$$N = 70(S')^{0.5}/\Delta \qquad \text{for} \quad \Delta^2/4\,900 \le S' \le 1.938 \tag{23}$$

Since $N \ge 1$, $S' \ge \Delta^2/4\,900$, and since the "maximum" minimum value of S from § 2.2.5 is 1.938, N in equation (23) is limited to this range. Thus, N is limited to the range; $1 \le N \le ((90/\Delta) + 0.5)$.

The single entry escalation, pfd_{es}, is related to the aggregate pfd_{ea} by:

$$pfd_{es} = pfd_{ea}/N \tag{24}$$

2.3 Single entry pfd values

From the preceding analyses, values of single entry pfds may be developed. The pfd single entry values developed in the following sections are applicable for aeronautical mobile telemetry systems. Telemetry systems parameter values are as follows:

T:	receiving station noise temperature = 250 K
B:	referenced bandwidth = 4 kHz
λ:	wavelength = 0.2 m
I/N:	interference/noise = 0.3846
$P(\Delta G)$:	probability of differential gain = 0.003611.

Using these values in conjunction with the ΔG versus S function, the excess margin and multiple entry factor for a Δ of 45°, results in the function shown in Fig. 6. As also shown in Fig. 6, the pfd versus angle of arrival is closely approximated by:

$$pfd \le -181.0 \qquad \text{dB(W/(m}^2 \cdot 4\text{ kHz))} \qquad \text{for} \quad 0° \le \alpha \le 4° \tag{25a}$$

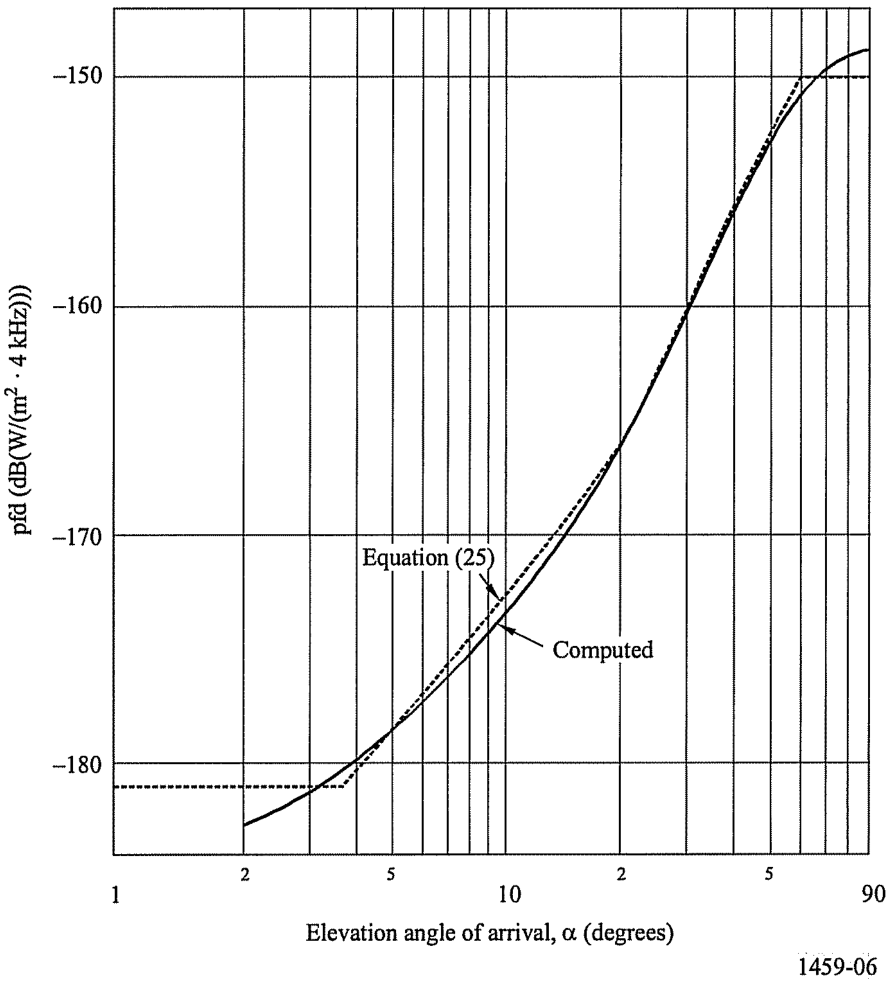
$$pfd \le -193.0 + 20 \log \alpha \qquad \text{dB(W/(m}^2 \cdot 4\text{ kHz))} \qquad \text{for} \quad 4° < \alpha \le 20° \tag{25b}$$

$$pfd \le -213.3 + 35.6 \log \alpha \qquad \text{dB(W/(m}^2 \cdot 4\text{ kHz))} \qquad \text{for} \quad 20° < \alpha \le 60° \tag{25c}$$

$$pfd \le -150 \qquad \text{dB(W/(m}^2 \cdot 4\text{ kHz))} \qquad \text{for} \quad 60° < \alpha \le 90° \tag{25d}$$

FIGURE 6

Single entry thresholds for aeronautical telemetry receiving stations due to interference from geostationary satellites



ANNEX 2

Mitigation techniques

1 Mitigation techniques for telemetry systems in the aeronautical mobile service

The following mitigation techniques should be reviewed and used to the extent practical towards achieving successful sharing with the BSS (sound).

1.1 Frequency avoidance

If possible avoid the use of those portions of the affected frequency bands. In the case of isolated telemetry sites (no overlapping air space with any other site) with a light testing schedule, it may be possible to avoid use of portions of the bands allocated to BSS (sound). In the case where many site coverage overlaps occur and simultaneous testing occurs, frequency avoidance may not be possible.

1.2 Polarization discrimination

In situations where it is possible for telemetry systems in the aeronautical mobile service to use opposite polarizations than those employed by BSS (sound) systems then some polarization discrimination may be achievable during the worst-case interference scenario when the BSS (sound) transmit and the telemetry receive antenna boresights are in near alignment.

1.3 Modulation and bandwidth considerations

There are several types of modulations and bandwidths used in telemetry systems in the aeronautical mobile service with a general trend towards becoming all digital. Use of digital modulation will facilitate the use of FEC coding techniques that would provide a higher degree of immunity or coding gain against BSS (sound) interference. Also from the standpoint of the interfering BSS (sound) signal being digital, will exhibit noise-like interference into the telemetry signal.

pfds are currently specified in a 4 kHz bandwidth at these frequencies. When the interfered-with signal is analogue or digital, limiting the interference levels in such a narrow bandwidth may lead to overly protective criteria. The use of more appropriate averaging bandwidths for particular sharing situations can more accurately represent protection requirements. For this case a 400 kHz averaging bandwidth can be used.

1.4 Telemetry airborne transmit antenna diversity

An important parameter in telemetry systems in the aeronautical mobile service is the signal availability. Manoeuvres of the airborne test vehicle can result in severe fading of the telemetry receive signal which typically follows a Rayleigh distribution. In some cases it is feasible to employ multiple transmit antennas along the body of the test vehicle to provide transmitter antenna diversity which could result in significant reduction of signal fading.

1.5 Telemetry site diversity

Some telemetry test ranges in the aeronautical mobile service employ two or more receive antennas. If these antennas can be arranged to provide site/space diversity a significant reduction in Rayleigh signal fading would be achieved. Also properly spaced receive antennas may result in avoidance of boresight-to-boresight interference scenarios and boresight-to-sun scenarios further improving telemetry signal availability and improving sharing. Combining frequency and site diversity would further reduce the fading margins.

1.6 Aeronautical telemetry test range geometry

In most interfering situations boresight-to-boresight scenarios will result in worst-case interference. If the previously described countermeasures are not viable or sufficient, a flight path for the test vehicles may be selected so as to avoid the most critical azimuths corresponding to near boresight conjunction and the avoidance of lower elevation angles. The particular arrangement and degree of success achievable will depend on the mutual spatial position of the test range telemetry receive antenna and BSS (sound) interfering transmitter.

Perhaps the single most effective mitigation technique from the aeronautical mobile telemetry standpoint would be to avoid telemetry antenna main lobe conjunctions with geostationary satellites. This case has been analysed for the 1 452-1 525 MHz band and it is estimated that about 20 dB of additional protection could be achieved at very low angles of arrival to about 5 dB at near zenith. The extent to which this technique can be employed depends on the geometry of the test ranges and the flight patterns which are not known at this time.

1.7 Aeronautical telemetry receiver interference cancelling techniques

Active suppression of interference is regularly used in dual polarization FSS and fixed service radio systems and on many occasions where specific difficult sharing scenarios occur. Significant interference suppression may be achieved depending on the fading dynamics. Such techniques could be a means of ameliorating particular interference situations that occur.

1.8 General sharing assessment

Even under the most favourable geometric conditions with mitigation techniques, it is extremely unlikely that a successful sharing could be achieved under co-coverage, co-frequency conditions, considering that the required pfd for the BSS (sound) service is of up to –122 dB(W/(m^2 · 4 kHz)).

However, under favourable geometric conditions and where BSS (sound) satellite antenna discrimination to the telemetry receiving antennas in the order of 30 dB can be achieved, there is a reasonable expectation of successful sharing for low-power systems, i.e. in the order of –138 dB(W/(m^2 · 4 kHz)). However, this value is not typical for BSS (sound) systems.

2 Mitigation techniques to facilitate sharing with BSS (DSB) systems

2.1 BSS (sound) systems

It is normally presumed that new systems in the planning and early implementation stages have more flexibility in choosing operating parameters that will facilitate sharing with existing services. The following lists some possible mitigation techniques that could be considered applicable to the BSS (sound) service to alleviate sharing. Also the results of different ITU-R studies agree with the views stated below on the feasibility and applicability of these mitigation techniques.

2.2 Orbit location

The selection of orbital locations that minimizes exposure and spill-over into critical mobile aeronautical telemetry (MAT) sites is a possible mitigation technique. The ITU-R considers that it would be very difficult to select orbital locations to minimize exposure to the affected services. The BSS (sound) expects to offer a worldwide service, and the countries who use MAT systems are spaced around the world so that it is impossible not to illuminate one or more of them. Furthermore, in many instances there are constraints on the choice of orbital locations available to provide a viable BSS (sound) service. Therefore, the ITU-R does not believe that significant advantage can be gained from this technique.

2.3 Modulation and implementation

This involves the employment of efficient modulation and channel coding schemes, and utilization of path diversity techniques that minimize pfd requirements in achieving the desired level of system performance and availability.

The comments of the ITU-R on this mitigation technique is that it has been diligent in its search for efficient modulation and channel coding schemes. Indeed, the work discussed in ITU-R in recent years has been innovative and significant in its ability to enable spectrum efficient systems to be considered. It is not likely that any further improvements will lead to major reductions in the necessary pfds, and hence improvements in the sharing scenario.

2.4 Spectrum spreading

Employing spread spectrum techniques reduces the pfd by the inverse of the spread ratio (spread bandwidth/unspread bandwidth) and increases the interference immunity by the spread ratio.

The ITU-R considers that spectrum spreading as a method of ameliorating sharing implies that there is sufficient spectrum allocated to the service to be able to spread the energy of the interfering signal over a larger bandwidth to provide a corresponding reduction in the pfd per unit of bandwidth, in this case per 4 kHz. Furthermore, in order to maximize this advantage, each interfering BSS (sound) service would need to utilize exclusive spectrum (i.e. no overlapping of the spread spectrum channels). Considering the relatively narrow-band of spectrum allocated to BSS (sound) by WARC-92, and further considering that this spectrum is shared with the broadcasting service (sound), spectrum spreading would not be a feasible mitigation technique to achieve sharing. This is illustrated by way of the following example:

The order of improvement in pfds to enable sharing appears to be greater than 30 dB. To achieve even 20 dB using spread spectrum techniques would, using normal pseudo-noise spreading systems, require a spreading gain of about 100, and hence use a spreading factor of 100. Given that the BSS band at 1.5 GHz is 40 MHz wide and we expect will, in time, be fully utilized, this would lead to a spectrum requirement for the BSS operation of 4 GHz if spread spectrum techniques were to be adopted.

2.5 Receiver performance

Maximization of the receiver figure of-merit, *G*/*T*, by employing low noise front ends and maximum gain antennas consistent with costs and the type of service being offered is a possible mitigation technique.

The ITU-R considers that RF device technology has now improved to the point that the low noise front end is not the limiting factor in setting the receiver noise budget. Typical receiver noise figures being considered range from 1-3 dB. As other sources of noise at the receiver, such as radiation from the ground, sky and surrounding objects, input filter losses, etc., contribute a significant portion of the overall receiver noise budget, we would therefore be suffering diminishing returns in considering reduction in receiver noise figure as a significant mitigation technique. Improving the gain of the antenna is feasible, and has been adopted in our attempts to realize cost-effective solutions. However, there is a limit to the amount that we can go in this direction when we consider that we are attempting to provide a service to mobile and portable receivers, and to offer a system which can be implemented at a price which can be afforded by all. Therefore, it would be difficult to achieve significant improvements in sharing by any possible improvements in the receiver *G*/*T*.

2.6 Satellite transmit antenna and coverage area

This mitigation technique consists of minimizing the satellite beam spill-over to the extent practical by utilizing beam shaping to conform as closely as practical to the intended service area.

The ITU-R considers that all proposals for BSS (sound) satellites pay careful attention to antenna engineering. The size of the antenna, and the need to minimize spill-over for efficient use of the BSS (sound) spectrum for our own purposes mean that beam shaping is already fully optimized. Also, while beam shaping will lead to more rapid roll-off of the close-in sidelobe levels (e.g. first sidelobe) thus facilitating sharing with services near the edge of the coverage area, such techniques do not improve the levels of the higher order sidelobes and hence will not improve sharing for systems located further from the edge of the coverage area which will tend to also correspond to lower elevation angles where the minimum pfd levels are required.

2.7 Highly-inclined elliptical orbit (HEO) BSS (sound) systems

For HEO systems, selection of orbital constellations that maximizes the elevation angles to affected MAT sites and making available Ephemeris (spatial and time information on the orbits) data to MAT operators are possible mitigation techniques.

The ITU-R considers that, given the large number of countries using fixed systems and the incomplete information about the location of these systems, it is not likely that any major improvement can be gained for HEO systems, other than those already achieved for the benefit of the broadcast service.

2.8 Frequency avoidance

This consists of selecting that part of the spectrum allotted to BSS (sound) least utilized by MAT systems when possible.

The ITU-R considers that this mitigation technique, while not representing in the true sense sharing, appears to be the only one which can be realistically exploited. The ITU-R realizes that, in the case of MATS, some of the band occupied by the MAT systems are safety of life systems. It would appear reasonable that, if at all possible, these elements of the MAT service occupy that part of the spectrum not occupied by BSS. It would make reasonable sense to require protection of this part of the service at the proposed levels.

The overall conclusions of the ITU-R on the above mitigation techniques to be applied to the BSS (sound) is that, except for the frequency avoidance technique, the sum of the improvements expected from the application of these mitigation techniques will not be nearly sufficient to ensure that successful sharing can be achieved. That being the case, the ITU-R considers that any improvements in sharing that may be achieved by the application of these and any other mitigation techniques would need to ensure that all administrations would have the capability of implementing the BSS (sound) service in the appropriate band allocated by WARC-92 and without the need for major constraints being placed on the level of service that can be provided.

3 Practical measures to permit inter-service sharing

When interference calculations are being made, worst-case scenarios are likely to be used, which could tend to lead to the conclusion that co-frequency or co-channel sharing by different services cannot occur. General technical parameters are used to establish appropriate sharing criteria. Those parameters may not reflect the actual proposed usage by administrations.

Where an administration wishes to establish a new system and appropriate sharing criteria have not been finalized, the measures outlined below should be considered to ensure that harmful interference is not caused to the existing service or to the proposed new service.

3.1 The affected administrations should identify specific areas, or installations, where such interference is likely to occur. It may then be possible to take specific action to adequately protect such areas or installations.

3.2 Initially, geographical separation will be a consideration, but as adjacent border areas will be most affected, this option may be limited.

3.3 When specific installations or sites have been identified as being affected, practical methods such as interference cancellers, special screening, and adaptive antenna systems may be implemented (see Recommendation ITU-R SM.856).

3.4 Modifications to existing channelling arrangements for systems in the fixed service may also need to be considered, provided this approach is consistent with economic advantage.

3.5 In the longer term, moves to the use of improved transmission techniques, such as spread spectrum (see Recommendation ITU-R SM.1055), coding techniques, automatic power control, and energy dispersal, may further facilitate inter-service sharing.